OL. XXIX. — No. 9. SEPTEMBER 1952.

Monthly Bulletin of the International Railway Congress Association

(English Edition)


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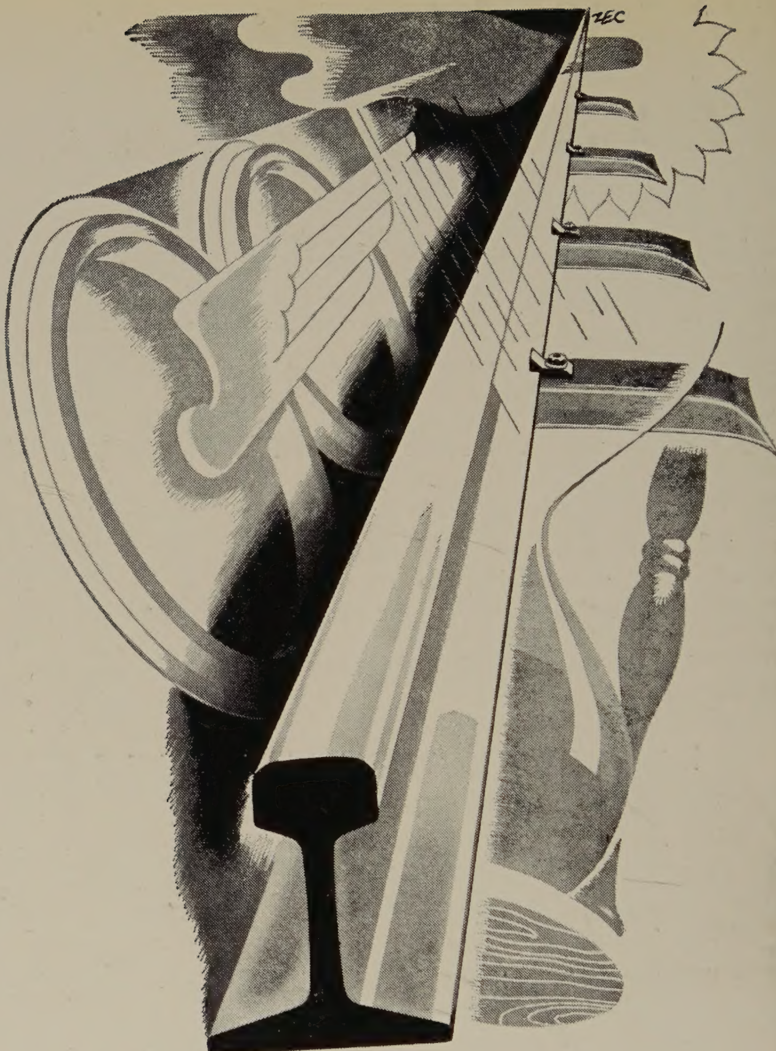

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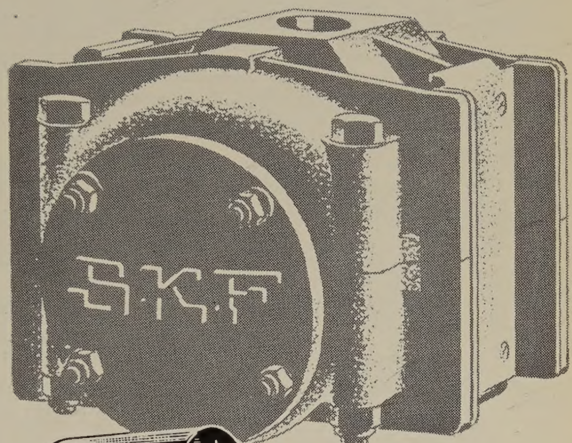
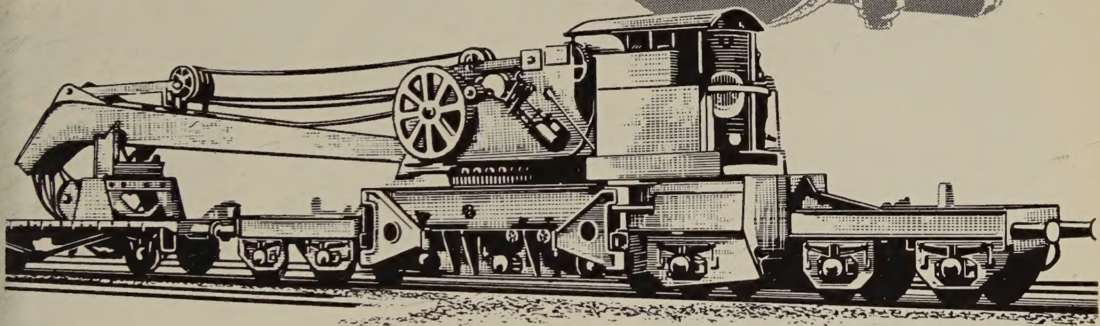
To reduce the time taken to reach an accident and to conform with modern Swedish practice, the breakdown cranes are equipped with SKF roller-bearing axleboxes.





Breakdown crane of the Swedish State Railways

Maximum working capacity
with outriggers: 50 tons at 18 ft. radius
without outriggers: 10 tons at 19 ft. radius

Maximum reach: about 39 ft.
Capacity with outriggers: 6 tons
" without outriggers: 3 tons

Maximum height of lift: *about 39 ft. above rail level*
Maximum load per axle: *13 tons*
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An edition in French is also published.

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .257 (493)]

New signalling installation at Soignies station,

by L. DEVILLERS,

Chief Engineer, Belgian National Railways.

INTRODUCTION.

It was in 1903 that the first electrically controlled station signalling was installed on the Belgian Railways. Since then, more than ninety power-operated boxes of the same type, which has become standard, have been built. They comprise individual operation of each point and each signal and the main locking is essentially by a mechanical panel.

In 1936, the Belgian National Railways (S.N.C.B.) put into service a box with route levers. In this type of box, the operator no longer creates the path of a movement by consecutive operation of each appropriate point lever to set the points to the required position. By the operation of a small handlever, he sets in one operation all the points on the desired path in the correct position and all the signals are lifted as soon as the whole of the safety conditions are fulfilled. The inherent rapidity of operation of this system provided an easy method of working the very complicated station of Brussels-Midi, by the installation, in 1940, of an electric box with route levers. A similar box serves the Brussels-Nord station, and two new boxes are being built.

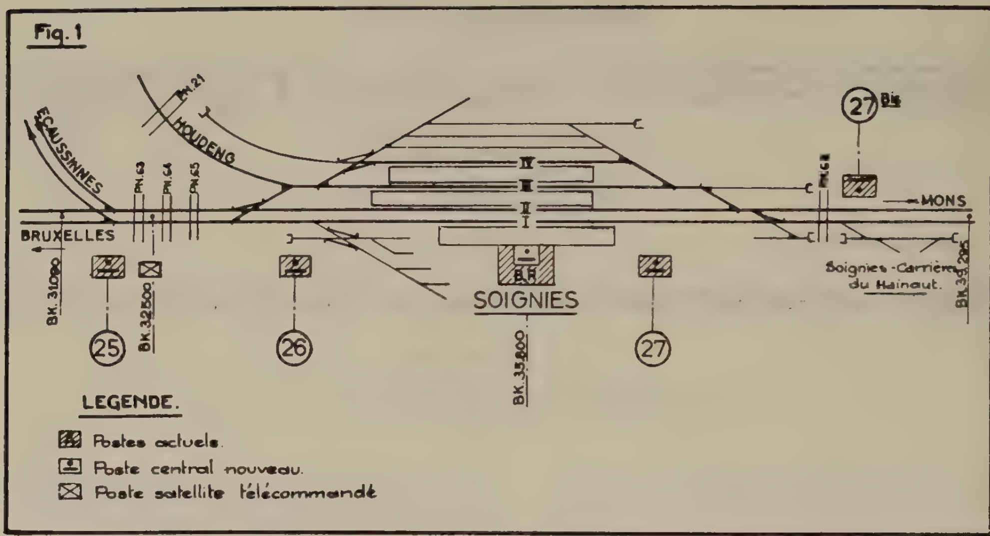
The events of 1940-1945, however, interrupted the progress which would have been made in the provision of route lever boxes.

Following the war, the S.N.C.B. wished to restore, as quickly as possible, security of operation, and rebuilt to the former design most of the standard type boxes which had been destroyed. At the same time, however, consideration was given to the all-relay boxes, the first of which had, in other countries, shewn the application of comparatively new trends.

In comparison with the best-equipped route-lever boxes, these electric boxes seemed to offer the following several advantages :

1) smaller and more convenient equipment, owing to the elimination of mechanical parts, and particularly the locking table;

2) ability to operate, at any distance whatever, with a minimum of cables,



Explanation of French terms :

LEGENDE = *KEY.* — Postes actuels = Existing boxes. — Poste central nouveau = New central box. — Poste satellite télécommandé = Remotely-controlled box.

remote and complicated lay-outs of points and signals;

3) possibility of coping with the most difficult exigencies of operating, without increasing the number of signalmen by the same proportion.

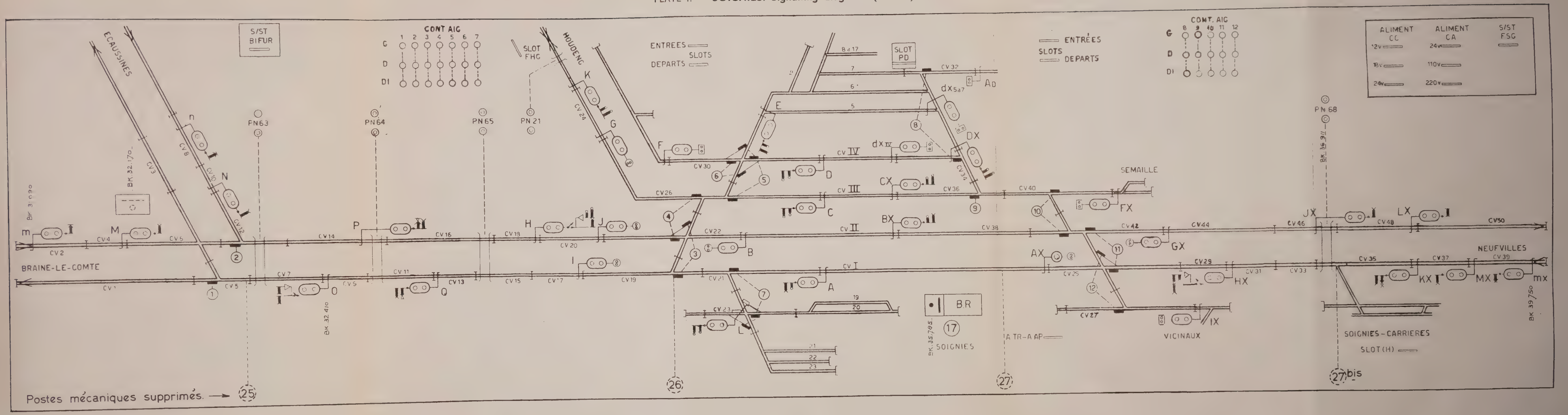
* * *

As a firts installation, the S.N.C.B. chose the station of *Soignies* 35 km (22 miles) from Brussels, on the Brussels-Paris line (see fig. 1).

The section between the two extreme signals was served by two mechanical boxes, with Saxby type levers, built in 1909. These boxes were due for renewal (boxes 26 and 27) (fig. 2). The line from Brussels to Quévy, the frontier station on the line to Paris, was included in the programme for electrification of 1 500 km (932 miles), and was subse-

Fig. 2. — Box 26. Interior view.

PLATE I. — **SOIGNIES.** Signalling diagram. (T.C.O)



quently to be equipped with suitable colour-light signalling. In addition, the booking office had been completely destroyed during the war.

It appeared advisable to profit from the reconstruction of this building by providing the necessary accommodation for a modern electric signal box to replace the two mechanical boxes. It was then easy to locate there also the control equipment for track and signals remote from the station and to abandon the two old mechanical boxes (25 and 27*b*) which covered it. By the selection of an all-relay

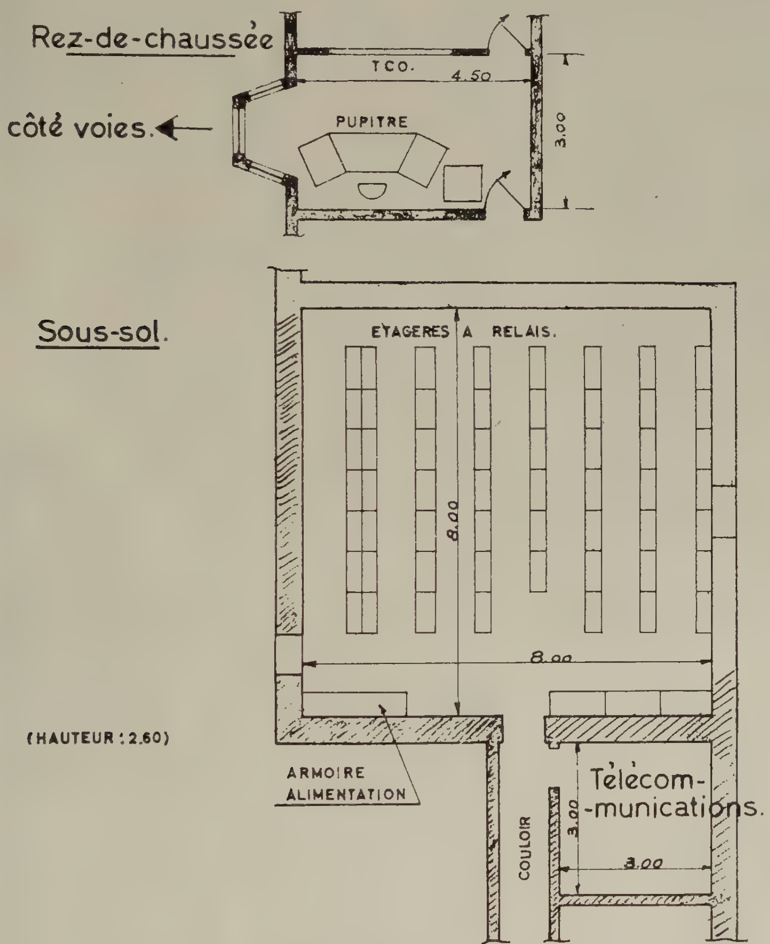


Fig. 3. — *Soignies.* Arrangement of accommodation.

Explanation of French terms :

Rez-de-chaussée = Ground floor. — Côté voies = Track side. — Pupitre = Control desk. — Sous-sol = Basement. — Etagères à relais = Relay racks. — Hauteur : 2.6 = Height : 2.60. — Armoire alimentation = Power supply cabinet. — Couloir = corridor. — Télécommunications = Telecommunication room.

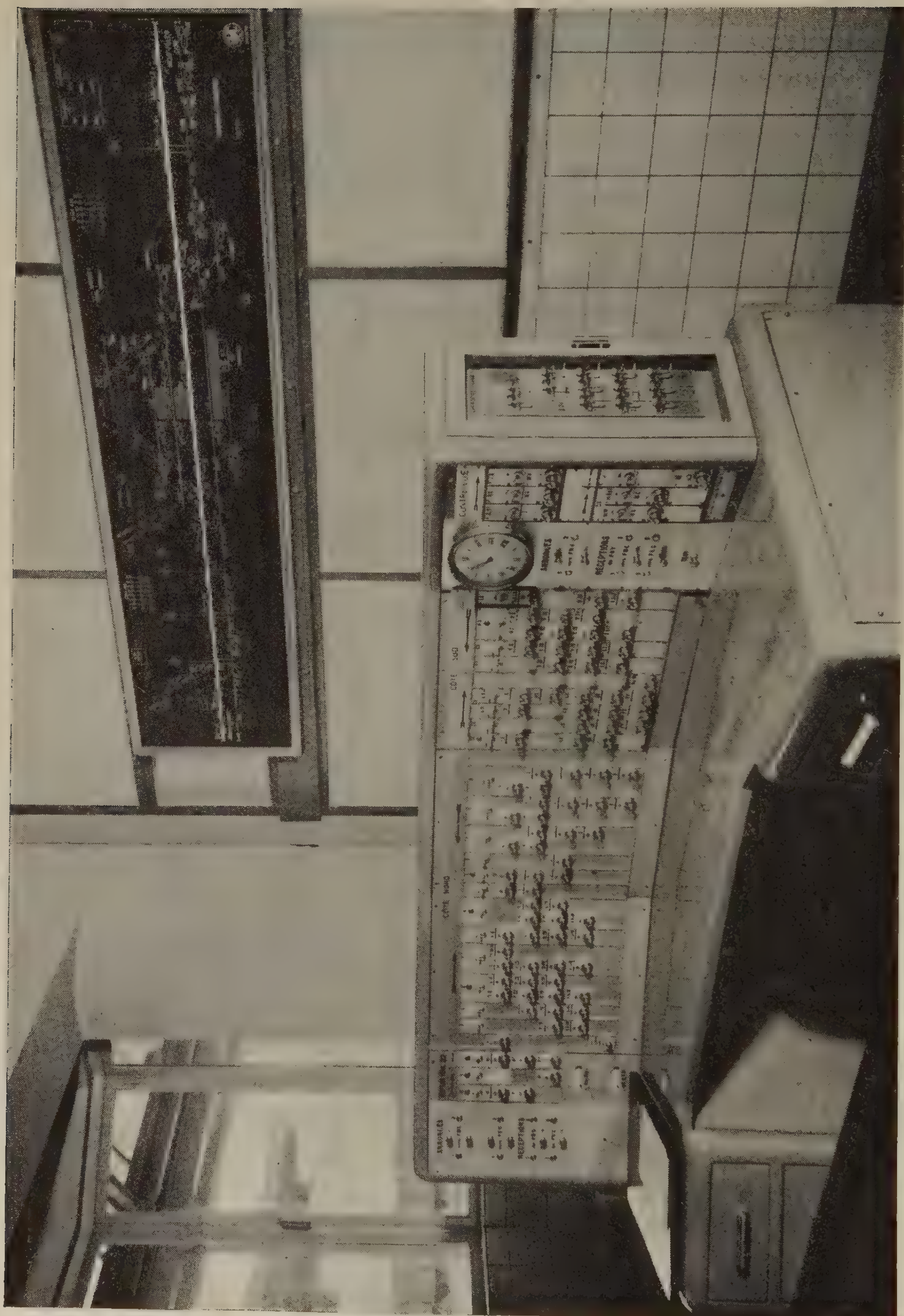


Fig. 4. — Interior view of main box. In the foreground is the control desk. Above, on the rear wall, is the illuminated visual control panel (T.C.O.).

box, with free levers, the section for box 25, located 3.5 km (2.17 miles) from Soignies station, could be controlled by cable.

In brief, the new electric box and its sub-box displace four of the old mechanical boxes and the total length served extends from km 31.100 to km 39.300. It includes four level crossings of minor importance, equipped with automatic lights. The complete installation is covered by one operator.

I. — MAIN BOX.

Designed, since April, 1949, and erected by the Compagnie Westinghouse and the « Ateliers de Constructions Electriques de Charleroi », the power-operated box has grown from the technique developed from the former company in France. It has had to be adapted to the operating arrangements of the S.N.C.B. and to the standard outdoor equipment of this system.

The installation comprises :

— 32 light signals;
20 sets of points, 48 track circuits;

— 94 different routes to be signalled (plate 1).

A. — Description (figs. 3, 4 and 5).

The control panel has free route buttons, without mechanical lock or screw. Its reduced size has allowed it to be installed in a small space, which also contains the separate illuminated visual control panel (T.C.O.), set in front of the operator.

Control is by automatic re-set buttons, which can take up three positions :

a) a neutral, rest, position, which is stable;

b) a push-in position of control, which must be held;

c) a pull-out position for cancellation of route, which must be held.

Fig. 5. — Cancellation of a path (button pulled out).

Buttons relating to routes authorised by the same signal are, in general grouped in one or two vertical columns. The ranges are in an order which corresponds noticeably to the relative remoteness of the signals from the box.

Fuses and switches are in boxes, located in a wall cupboard behind the operator.

Locking gear is all-electric, operating only during the *forming* of a route. Locking is done by relays grouped in

functional ranges on racks arranged in a room immediately below the control desk (1).

On a wall of the relay room, the cables from the equipment on the line (points, signals, track circuits) as well as the telegraph cables and the cables to the sub-box, are led to a distributor panel.

B. — Principle of operation.
(Plate II).

Each route button works directly on to a group of relays, connected under a single cover, called a « routing group ». A « route » is a combination of roads and track apparatus between two signals and suitable for service in both directions.

A single route can comprise several paths. Thus, for example, on the route covered by the signals C and Q there are three paths which can be seen from Plate I :

C → Q (depart of train) : button No. 81;

C → I (start of shunt) : button No. 87;

I → C (return from shunt) : button No. 42.

Thus the « route group » is also known as the « path group ».

As soon as a route group button is pressed, the desired path is formed by closure in the desired position of the point controlling relays in the box. These rocking relays (CAW) are selected by route relays (DR). A « rocker » selected only changes position if it is not included, in its present position, in the path which is being set up.

The selected path now *set up* (point rockers CAW and path locking rockers IR in the required positions), the diagrammatic trace lights up on the visual control panel and the lamp located in the centre of the route button lights, whilst the button returns to the neutral position.

Any other path, conflicting with the first, can still be selected but no action takes place in the box. This selection does not come into force subsequently, as the registration of paths has not been provided for in the Soignies box (registration consists of reserving until operating conditions are suitable, a selected path, when an earlier conflicting path is set up). On the other hand, a device, known as the « engaged order », requires the repeating, at a suitable time, of the selection which has been ineffective.

When the points on the line are in agreement with the positions taken up by the corresponding rockers, and the running conditions are met, the path is « *made* » and the white lamp of the signal is illuminated on the TCO. Immediately the signal on the line, which authorises the movement, comes off, the red lamp which signifies a stop signal, goes out.

The path is maintained until it is *cancelled*, either by pulling out the corresponding control button or *automatically* by the passage of the train. It should be noted that a path can be « cancelled », (switch rocker returning to normal position) without thereby being « freed ». The point rockers remain immobile and are freed individually and successively by the passage of the train beyond their respective isolated zones, known as « isolated transit zones ». This is a characteristic of « flexible working ».

(1) The choice of relays and the method of cabling were decided in 1949.

PLATE II. *(Sheet 2).*

KEY.

ORDERING OR CANCELLING OF PATH.

31 route button H to track II.
36 route button H to track II permanently.
51 route button J to track II.
78 route button B to J.
S_1H - R. for selection of train movements from H.
S_2H - R. for selection of shunt movements from H.
SJ - R. for selection of reverse movements from J.

GROUP 13.

CR - R. for path control.
NR - R. for manual cancellation of path.
CPB - R. for permanent setting.
DRN - R. for route repeating — normal direction.
DRI - R. for route repeating — reverse direction.
DPB - R. for permanent setting.
NRA - R. for automatic cancellation.

TRANSIT COMBINATIONS.

TR - P - R. for normal direction.
TR - I - R. for reverse direction.
NTR - R. for cancelling transit.
V - R. for track.
DV - R. for repeating track relays.

FORMATION OF ROUTE.

CAW - R. rocking relay for point control (two positions : G, left; D, right).
IR - R reverse locking (N, normal; R. reverse).
KTR - R. auxiliary transit control relay.

LOCKING AND CANCELLATION OF ROUTES.

ZAN - R. approach section relay.
IAN - R. route approach locking relay.
RPV - R. auxiliary for cancelling approach locking.
NIAN - R. cancellation of approach locking.

PRIMARY CONDITIONS.

KV - R. for control of isolated sections.

POINT OPERATION AND SETTING OF ROUTE.

SAW - R. series relay for point operation.
RU operating contactor.
KAW - R. two-element relay for point control.
KR - R. route control relay.

OPENING OF SIGNALS.

CSA_1 - R. for setting signal (panel 1) at stop.
CSA_3 - R. for setting signal (panel 3) at stop.
COB - R. relay controlling entrance to occupied road.
CSP - R. relay for controlling signal in automatic block position.
KFS - R. controlling signal closure.

CLOSING OF SIGNALS.

C. Aub. - R. calling on signal relay.

Note. — R. = relay.

Certain paths are needed for trains running through the station without leaving the direct main lines and these can be controlled on a « permanent lay-out ». Supplementary path buttons are governed by it. A path set up by a permanent lay-out order is identified with a section of line worked by automatic block and the signalman must not interfere in the passage of consecutive trains; the corresponding signals are normally off and their setting to stop is controlled by the occupation of the track circuit ahead. The closed signal, illuminated with an eye is passable, subject to the restricted conditions for passing. On the other hand, manual closing when the approach sections are not occupied, or holding closed by drawing on extinguishes the eye and gives the red light an absolute stop value. Simultaneously, the « permanent lay-out » characteristic is cancelled.

Finally, shunting movements, authorised by a signal aspect different from that which normally controls the running of trains, are governed by route buttons appropriate to them. Signalling of these movements is not subject to approach locking nor to calling on. Control of closing of signals is always manual and is done by drawing out the button corresponding to the path covered. It is only then that the shunting path is destroyed, whilst it is freed, as for train movements, according to the conditions of flexible working.

The whole of the diagrams relative to the installation cannot be given in this article. We have considered that a summarised illustration of the various circuits relative to a single signal, such as H, would however be of interest to signalling experts. These circuits are shewn in Plate II.

C. — Visual control panel (T.C.O.) (fig. 6).

When the zone served by a single box is as extensive as that of Soignies, a visual control panel is essential for operation.

Located in front of the operator, it reproduces diagrammatically and completely, the track installation controlled as well as the intermediate sections included between Soignies and the neighbouring boxes operated by signalmen.

When no movement is in preparation, only the platform track circuits and the closed signals are illuminated, in white and red respectively. A path set up is shewn by continuous white lines.

Lack of control, or a discrepancy in the position of a controlled set of points is indicated by the lighting of a red lamp relating to these points, in the upper portion of the T.C.O.; outside the line diagram.

As soon as a path is made, the white lamp of the signal lights up and simultaneously the opening of the signal is shewn by the extinction of the red lamp.

The T.C.O. further pinpoints the connections established between the main box and the neighbouring boxes served, as well as the aspect of the level crossing light signals.

The panel is constructed in such a manner that it can easily be revised if modifications are subsequently made in the line lay-out.

For this purpose, it is made up of a

metallic plate, bored all over in quincunx pattern and covered with glass panels.

The holes bored in the metal plate allow of the fixing, in accordance with the line diagram, of the lamp holders of which the plate forms the return conductor of the power cicuit. Small movable separators, fixed at the same time as the lamp holders, canalise the light along transparent lines or spots in the painted glass. At the same time as the track diagram is outlined on the glass, the point numbers, signal indications and all the necessary operating information is included in the painting.

Whenever track equipment is altered, it is only necessary to move the lamps and separators — which is easily done — and retouch the painting of the glass panel as necessary.

II. — REMOTELY CONTROLLED SUB-BOX (fig. 7, 8).

This covers the section including the junction to Brussels and Ecaussines, 3.5 km from the main box. Direct control of this box and the two sets of points and three signals was acceptable. Remote control was, however, selected, despite the small number of paths to be made, so as to allow practical experience with this type of installation and to initiate personnel into its new technique, with a view to its wider application.

All the forming and locking route relays are grouped in the sub-box, which also houses a feeder sub-station and some of the telecommunication equipment.

A small control table, with free buttons

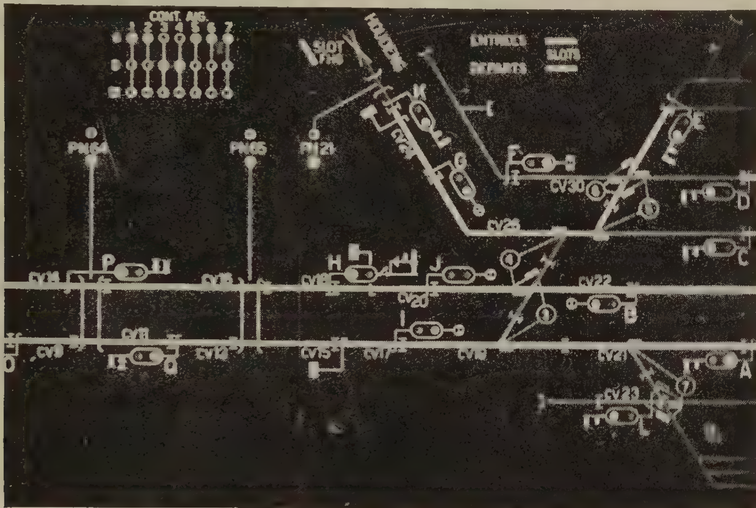


Fig. 6. — Portion of the visual control panel. In the top, left, will be seen the indicator lamps for position of points (left or right) and the individual displacement light (DI).

of the type used in the main box, provides for occasional local control of the paths.

Principle of remote control (1).

The method of remote control by cable is developed from the centralised control system used in 1934 by the Westinghouse Company on the line between Houilles and Sartrouville, on the Paris-Le Havre line. From the Saint-Lazare station in Paris all line equipment on this section is controlled and operated individually.

The apparatus installed at Soignies is of the complete route type.

The sub-box is connected to the main box by a twin-conductor cable, fed at 24 V DC.

***

The operation of a route button at the main box causes the emission of a series of 16 impulses, corresponding to the switching on and off of the current.

Fig. 7. — Ecaussines junction and the sub-box (when this photograph was taken the points were still mechanically operated).

In the same way, any alteration, intentional or otherwise, in the position of a component of the sub-box starts the emission of a similar series of 16 impulses.

The extension by an arrangement of relays — of an improved telephone type, known as TS relays — of certain of the impulses which are normally short, is used to form a code. Only the long impulses (3/10″) are active, they are called registering impulses; the short

(1) For a more detailed description of this system, see « Centralised control of operation on the Blaisy-Bas-Dijon section », by M. GAILLARD, Chief Engineer S.N.C.F. *(Revue Générale des Chemins de fer*, May, 1950, Dunod, Paris.)

impulses (1/10″) are called spacers. The relays which influence the impulses are brought into operation, automatically, by the control and operation equipment, so as to translate the number of the code applicable to them.

impulse which gives it priority of transmission over all control codes. In the two types of codes, the seven following impulses, prolonged in threes, select the « receiver ». The thirty-five possible combinations define the capacity of the

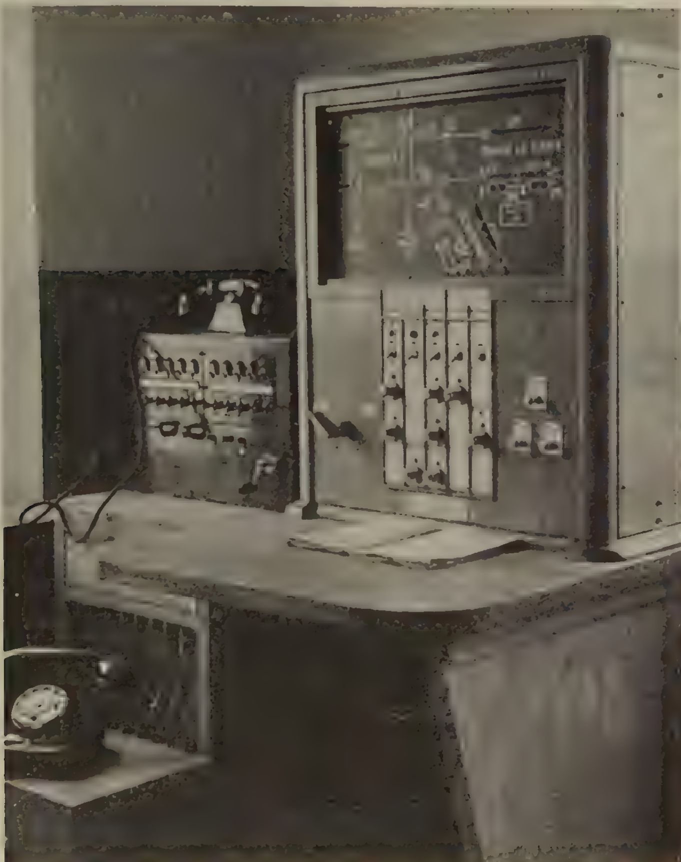


Fig. 8. — Desk for occasional local control, located in the sub-box.

A « control code » arising from the sub-box is always commenced by a short impulse; an « operating code » from the main box is always started by a long

system, which is therefore 35 receiving points. Each of these is identified by its indication, made up of figures, giving the range of the long impulses. On a receiver

being selected, the « order » transmitted is characterised by the prolongation of one of the impulses 9-15 and is provisionally registered. Several orders for one receiver can be transmitted simultaneously, the sixteenth impulse, which is always long, ensures the distribution of the order :

— on the component of the satellite box, in the case of operation;

— on the visual indicators of the T.C.O. of the main box in the case of control emitted by the sub-box;

— A milliammeter in the control panel of the main box provides a visual indication of the passage of « orders ».

— The relays used for remote control and operation are of the reinforced telephone (TS) type; they are grouped on the racks and enclosed in boxes (fig. 9). They have no security function. An operation on the line does not take place if all the safety conditions in the locality are not completely fulfilled. These conditions are translated in the sub-box by controls and locks effected by the signalling relays, of a higher class.

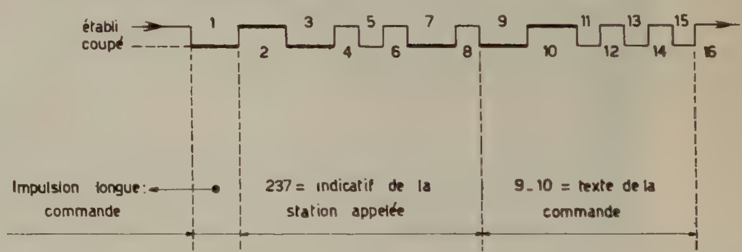
III. — LINE EQUIPMENT.

The line equipment has been designed, installed, connected up and tested by the technical officials and electro-mechanical staff of the S.N.C.B.

Examples of codes :

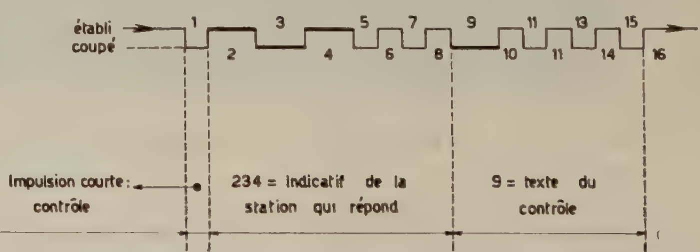
(a) Control path O/BC, including the left-hand setting of points 1 :

Line current :



(b) Reply of point 1 set up :

Line current



N. B. — établi = make. — coupé = break. — impulsion longue commande = long impulse control. — 237 = indicatif de la station appelée. — 237 = called point. — 9.10 = texte de la commande = 9.10 = order . — impulsion courte: contrôle = short impulse : control. — 234 = indicatif de la station qui répond = 234 = replying point. — 9 = texte du contrôle = 9 = reply.

A. — Point operating equipment (fig. 10).

The operating equipment is, from the mechanical point of view, of the type used generally throughout the system.

Fig. 9. — T.S. relays in boxes.

With a stroke of 300 mm (11 13/16″), the ratchet lever works locking hooks of the « Bussing » type and effects a movement at the points of 160 mm (6 5/16″). The correct positioning of the points is controlled by means of rods which work on a commutator incorporated in the operating equipment.

The motor used at Soignies is of the asynchronous, double squirrel-cage type, fed at a tension of 220 V, between phases.

Control of the positions taken up by the points is achieved in the cabin by two-element relays, which can each take up two positions.

B. — Track circuits.

The installation includes 48 track circuits of varying lengths. These are on the two lines of rails, fed at 110 V AC. The inductive connections will be adapted to the longest track circuits when the line is eventually electrified.

Regulation of the circuits was made in two phases :

(a) laboratory determination of the approximate value of the adjustable elements;

(b) setting at the site.

C. — Signals (fig. 11).

The signals are illuminated by day and by night. Their aspects have been described earlier [1]. They are made up of luminous units, independent and movable, grouped on three types of panel. Each unit has a 15 W lamp, with one centralised filament, supplied from a 110 V/7.2 V transformer.

The optical system comprises two clear Fresnel lenses and one coloured filter.

Combinations of lights are provided for the whole of the conditions of running by relays in metal cabinets, located at the base of the signals (see Plate II, control of signals).

(1) See *International Railway Congress Bulletin* for January, 1949.

D. — Post D and junction for Carrières du Hainaut.

To facilitate supervised shunting, which is done at certain times of the day, a section of accessory equipment has been left under the control of a small post with mechanical levers (Post D).

Movement desired by Post D which would occupy the section served by the main box are carried out only with permission. This authority is translated at post D by the locking of the protecting points and freeing of the signal control handles. The same occurs with the freeing of the point operation equipment, on the site, giving access to the « Carrières du Hainaut » siding.

E. — Level crossings (fig. 12 and 13).

The stretch served by the free lever box and its sub-box, includes five level crossings.

Level crossing No. 68, situated on a much-used minor road, is guarded and provided with gates, but train movements are communicated automatically by the track circuits.

The other four level crossings are on minor local roads, which are only little used. It has been possible to equip them with automatic road warning lights of the standard type.

The occupation of a particular group of track circuits changes the green light denoting clear track to the intermittent

Fig. 10. — Point operating mechanism with two push rods. Covers removed.

PLANCHE III

SOIGNIES : POSTES "TOUS RELAIS" — SCHEMA GENERAL D'ALIMENTATION.

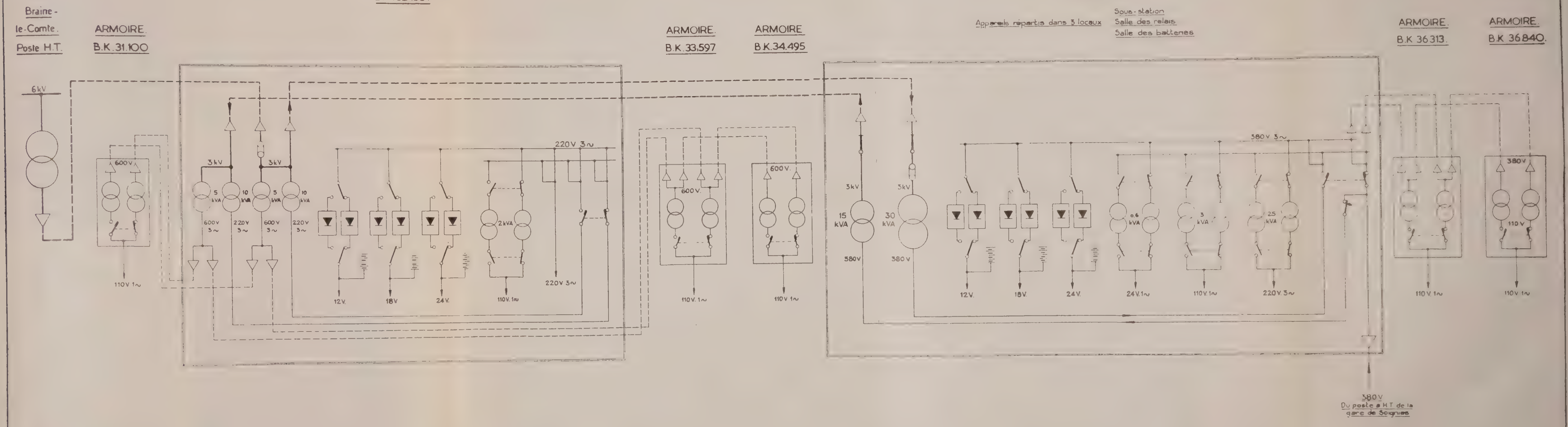


PLATE III. SOIGNIES : ALL-RELAY BOX. — GENERAL ARRANGEMENT OF POWER SUPPLY.

Braine-le-Comte : Poste H.T. — Braine-le-Comte : H.T. post. — Armoire B.K. 31.100 = Cabinet distance post : 31.100. — Poste satellite B.K. 32.155 — Sub-box, distance post : 32.155. — Poste Central — Soignies = Main box — Soignies. — Appareils répartis dans 3 locaux : sous-station, salle des relais, salle des batteries = Equipment located in three places : sub-station, relay room, battery room. — 380 V du poste à H.T. de la gare de Soignies = 380 V from H.T. post at Soignies station.

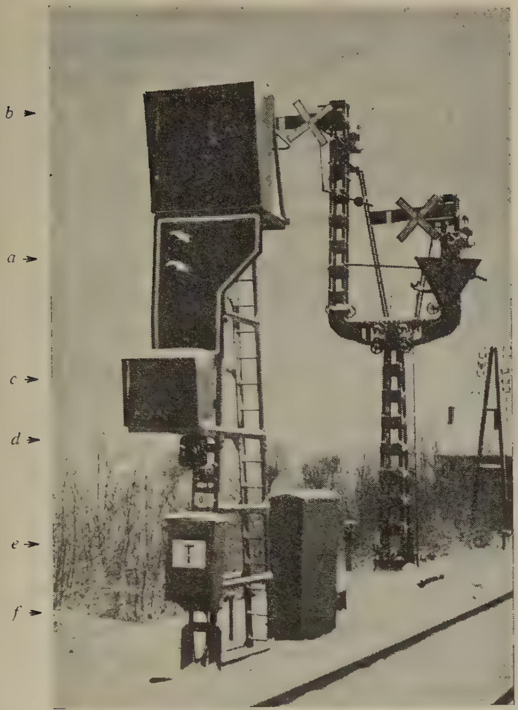


Fig. 11. — Light signal type III (crossing signal).

a) principal panel.
b) panel with direction arrows,
c) speed panel.
d) passing sight.
e) telephone cabinet,
f) relay cabinet.

Behind is the old mechanical semaphore signal; the arms are fitted with crosses to show that they are out of use.

red which announces the approach of a train. The intermittent switch comprises a mercury tube with oscillating level, in which the electrodes immerse; it can pass equally AC or DC current provided by the emergency battery.

The lamps, 24 W, 12 V, have a concentrated filament, with a rapid cooling, to give clarity to the intermittent nature of the illumination.

Correct functioning of the road signals is controlled at the central box by pilot lights on the T.C.O. A white light is shewn whilst the red lights have an intermittent red aspect.

IV. — POWER SUPPLY.

When the Brussels-Paris line is electrified, the Soignies installation will be connected to the general power supply from the traction sub-stations.

At present, the electrical energy is supplied by two H.T. transformer stations, located at Soignies and Braine-le-Comte,

Fig. 12. — Automatically operated level crossing signal.

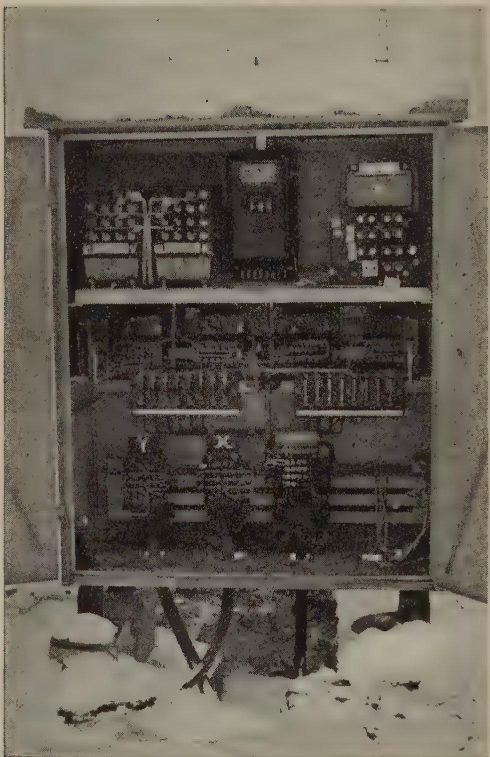


Fig. 13. — Cabinet containing relays and automatic intermittent switch for road signal.

on two separate distribution systems. The central box at Soignies has, therefore two input cables, one at 380/220 V from the local transformer station, and the other at 3 000 V from Braine-le-Comte. A transformer reduces the tension of the latter to 380/220 V also. A range of contactors, controlled by a voltmetric relay allows for automatic commutation of the signalling equipment from either source.

The sub-box is also served by the two feeders mentioned above, one by tapping the 3 kV cable connecting Soignies and Braine and the other by cable from Soignies where it is connected to the local supply and stepped up by a 380/3 000 V transformer. The two feeders are thus here at a tension of 3 kV and each of them is transformed to 220 V, 3-phase.

At this tension a range of commutators allows automatic commutation of the sources.

Finally, five metal cabinets arranged along the track for supplying line equipment are also connected by cable to each of the sources of supply. Those which stretch south of Soignies are connected to the 380 V lines of the main sub-station and the the others are linked to the sub-box where there are two transformers which distribute at 600 V the tension from the two available sources.

Apart from the outside cabinets, energy is distributed at 110 V to feed the luminous signals and the track circuits.

At the main box, it is available for the electrical equipment in the following forms :

220 V, AC 3-phase (point operation);

24 V, AC single phase (T.C.O.);

110 V, AC single phase (lamps and track circuits);

24, 18 and 12 V, DC (control and operating relays).

For each alternative tension, there is provided a pair of transformers with automatic change.

For each direct tension, there is an accumulator battery and two rectifiers working in parallel.

At the sub-box there is exatly the same arrangement, except for the provision of 24 V, AC, which is unnecessary.

V. — TELEPHONE CONNECTIONS (fig. 14).

The telecommunication equipment was modernized during the work of setting up the new box.

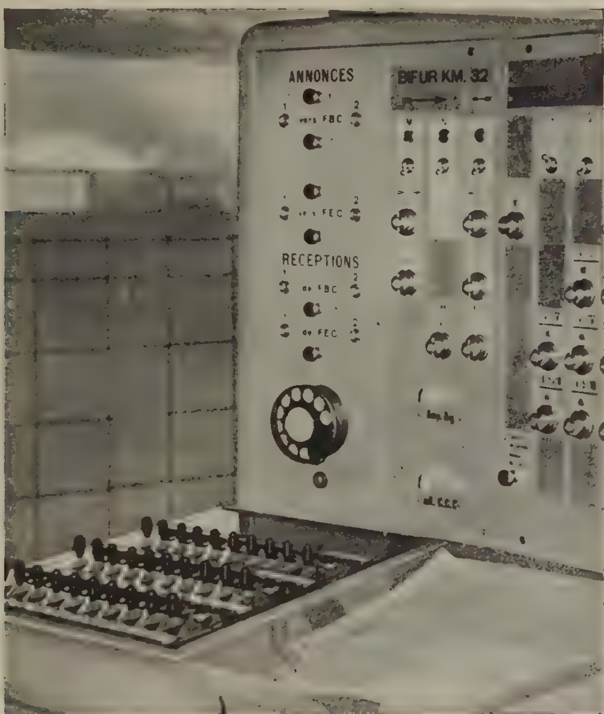


Fig. 14. — Telephone key board with dial mounted on control panel.

The automatic change from normal to auxiliary supply and thus the engagement of the rectifiers is shewn on the T.C.O. of the main box, by the control cable.

A diagram of the power supply is included in Plate III.

A board with all the telephone connections and call lights is embodied in the central signal equipment console. This board replaces all the various switchboards, key boxes and dispatching points which were formerly provided at the

signal boxes. This has necessitated the adoption on the board of an arrangement allowing communication with a line using a local battery, a line with a central battery, an automatic line and a dispatching circuit, all with one combined tele-microphone.

The accommodation specially reserved for tele-communications is provided with the following equipment :

— the feed current rectifier and the common accumulator battery;

— the clock control for station clocks, and particularly for the clocks on the vertical panels of the signallers' console;

— finally, an automatic ten-number commutator connected to the Braine-le-Comte box.

The local telephone cable system has had to be re-modelled following the elimination of the mechanical boxes.

Fig. 15. — Effect of heating points.

— a cable assembly with dividing brackets on which, in preparation for the electrification of the line, has been reserved the necessary emplacement for the future Brussels-Mons cable;

— a main distributor carrying the distribution and switching lines;

— two mounting plate assemblies controlled by the switchboard on the signallers' control panel;

— an assembly comprising the call identifiers for party lines, calling current generators and fuse regenerator;

The telephones to numerous signals are fed by a central battery. The suppression of feeds on the site has considerably reduced the maintenance requirements.

They are connected to the control post by a star-quart incorporated in the centre of some of the signalling cables. The conductors of this quart are distinguishable from the other conductors only by their arrangement, all other characteristics being identical.

Tests have shewn that the fairly intense noise which would result in ordinary cables from induction between neighbouring circuits not twisted was practically eliminated. Measurements have established that in the longest circuits the « level of noise » could be kept below 5 mv. without increasing the customary reduction.

This excellent result is very favourable for the exchange of communications when transmitting orders for overrunning the more remote signals.

VI. — MISCELLANEOUS.

A. — Heating of points (see figs. 15 and 16).

The two sets of points of the remotely-controlled junction 3.5 km from the main box are difficult of access.

In the case of sudden snowfall, it is not possible to get staff there for clearing the track equipment in good time. It therefore appeared necessary to provide electric heating of the points, trials with this method having been undertaken since 1950 at Linkebeek, on the line from Brussels to Charleroi with satisfactory results.

Each counter rail is provided, over a length of about 5 m (16′ 5″) with a heating element.

This element is composed of a copper-bronze case, of 17 × 7 mm (43/64″ × 9/32″) section. In this case are threaded nickel-chrome resistance wires in a ceramic insulation. The whole is then strongly pressed, so that the assembly, casing, wire and insulation, form a compact mass, tested at 1 500 V and capable of taking up various contours. The oval form of the elements provides a large area of contact with the rail. The emergence of the two ends of the resistance wire from the same end of the casing simplifies cabling. Their connection to the feeders is made in a special box fixed to the rail and filled with insulating material.

The specific load of each element is in the region of 2 to 2.2 w/cm, which provides an increase in the temperature of the rail of about 12° C.

The efficient operation of the appliance and its practical advantage were shewn on the first morning on which it was put

Fig. 16. — Heating of points : detail view.

into service. The points, counter rails and slides of the heated equipment were entirely freed whilst a fall of about 10 cm (4″) of snow covered uniformly the whole of the track.

Starting and stopping of the heating are remotely controlled from the main box, and during its use an hourly consumption of energy is 4 kW/h.

The proximity of the sub-station has allowed the cost of the cabling to remain low.

Fig. 17. — Fire detector-air dilation type, used in main box.

B. — Detection of fire
(figs. 17 and 18).

Fire detection devices have been provided in the relay room of the main box as well as in the neighbourhood of the relays and the high-tension equipment of the sub-box.

The detectors are of air dilation and pneumatic compensation type.

Those of the main box, combined with a continuous fusible wire, of helical spiral round the upper group of cable wires, cause only the sounding of the fire alarm, by breaking a standing electric circuit. The CO_2 extinguishers must then be brought into use by the staff.

The detectors of the sub-box, by shearing a metallic cable, bring the CO_2 distributors into action. Protection against fire is therefore automatic.

Behind the control desk of this post, a small cabinet contains the alarm bell and two lamps, which indicate the source of the alarm.

VII. — TESTS AND INAUGURATION
(figs. 19 and 20).

Trials with the all-relay box were greatly facilitated by the use of an assumed lay-out. This is a panel representing the track equipment. The operation and position of the fittings are simulated by switches and lamps. This table was connected at the main box to the outward terminals provided for connection to the line equipment.

All operations for creating and cancelling paths could thus be carried out and controlled in the box independently of the outside equipment.

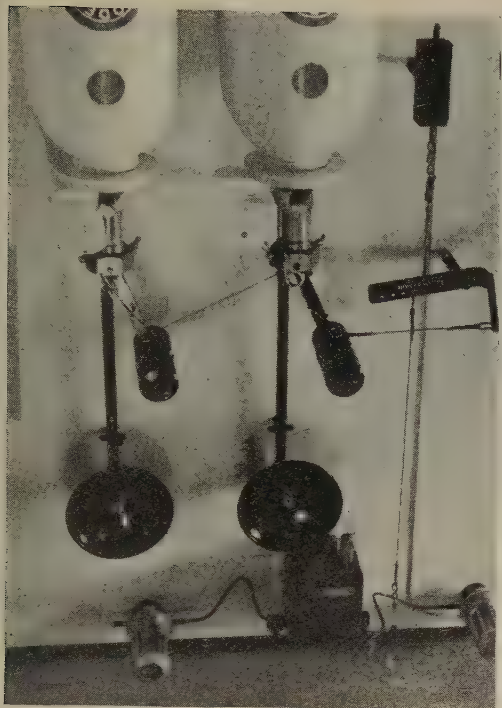


Fig. 18. — Detail view of arrangement for automatic discharge of CO_2 extinguishers.

In addition, the latter was tested separately through the respective cables.

Thence, by correct connection of interior circuits to the corresponding outward terminals of the cables when the service is inaugurated, the complete circuits are ready for work.

The date chosen for the inauguration of the new installation was the 26th January, 1952 (1).

There had been snow on the previous day. The track circuit and rod connections to be substituted for those which had previously been used for mechanical signalling were covered with a thick layer of snow. In spite of these unfavourable conditions, the taking over by the new boxes of the service of the section extending over 8 km (5 miles) was carried out within the prescribed time.

(1) Design started at the beginning of 1949. Work started in October 1950, but was interrupted for reasons outside the signalling work.

Fig. 19. — Working on inauguration, 26th January, 1952.

Fig. 20. — 26th January, 1952 : Inauguration of service. Substitution of electric operation for mechanical operation of points.

CONCLUSIONS.

Designed and erected jointly by the Westinghouse Brake and Signal Company (Paris), the Ateliers de Constructions Electriques de Charleroi and the S.N.C.B. (1), the Soignies installation has provided all concerned with an opportunity of meeting and reconciling different techniques.

The lessons, which have been learned, will allow us to proceed with confidence to further all-relay boxes.

The previous arrangements of normal boxes with individual or route levers with mechanical locking cannot be immediately abandoned. They have advantages in erection and maintenance, which result from long professional experience by high-class personnel. The new boxes, however, will certainly be favourably received by operating staff, whilst providing confidence amongst the technicians, and it can from now on be visualised that the early economy in their erection, added to the advantages they provide in operation, will give the all-relay box a large field of application.

(1) S.N.C.B. — Electric signal box department, M. DEGREZ, Principal Engineer; MM. PIERARD and PECHEUX, Engineers.

[624 2. & 691]

Girders embedded in concrete for composite structures,

by Dr. Ing. Hugo NEUFFER, Kassel.

(*Der Eisenbahnbau*, No. 3, March 1951.)

Composite deck structures are specially favoured since their maintenance cost is almost nil compared with that of purely metallic flooring. Moreover, the design is very simple as any work on metallic framing for the girders is rendered unnecessary. It may also be pointed out that the heavy slabs of concrete resulting from embedding the girders are particularly suitable for absorbing dynamic stresses. They show further advantages, namely low structural height and also the possibility of again making use of the old girders which will have been used for temporary work.

The disadvantages inherent in the use of flooring formed by girders embedded in concrete is due to the heavy consumption of girders, to the fact that the weight of concrete introduces a load which has no useful effect in the longitudinal direction of the girders (fig. 1*a*) and finally, because it is not possible to utilise fully the stresses for which the steel is calculated, since it is not permissible to exceed the flexure specified. This is the reason why in figure 1*a*, the stressing of the steel is limited to σ = 1 230 kg/cm² whereas the normal stress allowed is 1 400 kg/cm². All these drawbacks can be avoided by making the embedded girders as parts of a composite steel and concrete structure.

Figure 1*a* shows the ordinary flooring made up with embedded girders while figures 1*b* to 1*d* show floorings of composite design with embedded girders.

In order to allow a comparison between the two types, identical sections of concrete have been used in figures 1*a* to 1*f*, for a floor covering a deck of $l = 10.50$ m length and an overload in accordance with the load distribution plan S (1950). With the girder sections used as bases of comparison, the stresses in the concrete have been found to be excessive.

In order to secure protection for the girders and unstressed cross members against corrosion, it is necessary that the concrete which encloses them, should contain at least 240 kg of cement per cubic metre. Thus, in the transverse direction, this rich concrete mixture only serves to form a level deck. In the longitudinal way, the whole section of the concrete, which is relatively large, remains statically entirely inactive; for this reason the use of flooring made up of embedded girders is quite uneconomical.

Figures 1*b*, 1*c* and 1*d* show embedded composite girders, which have been calculated according to Prof. DIRCHINGER's method for composite structures (*Der Bauingenieur*, 1949, p. 329). As regards the moduli of elasticity $n = \frac{E_e}{E_b}$, the coefficients were taken to be n = 17.5 for the permanent load and n = 7 for the overload.

Figure 1*b* shows the same sections of concrete and of steel as does figure 1*a*, but including the bonding. It will at once be noted that here the stress in the concrete. σ_b = 87 kg/cm² (permissible stress for concrete at 300 kg being $\sigma_{zul.}$ = 80 kg/cm², and for 450 kg $\sigma_{zul.}$ = 100 kg/cm²) is completely utilised, while on the other hand, the mechanical properties of the steel are very insufficiently utilised, since σ_e

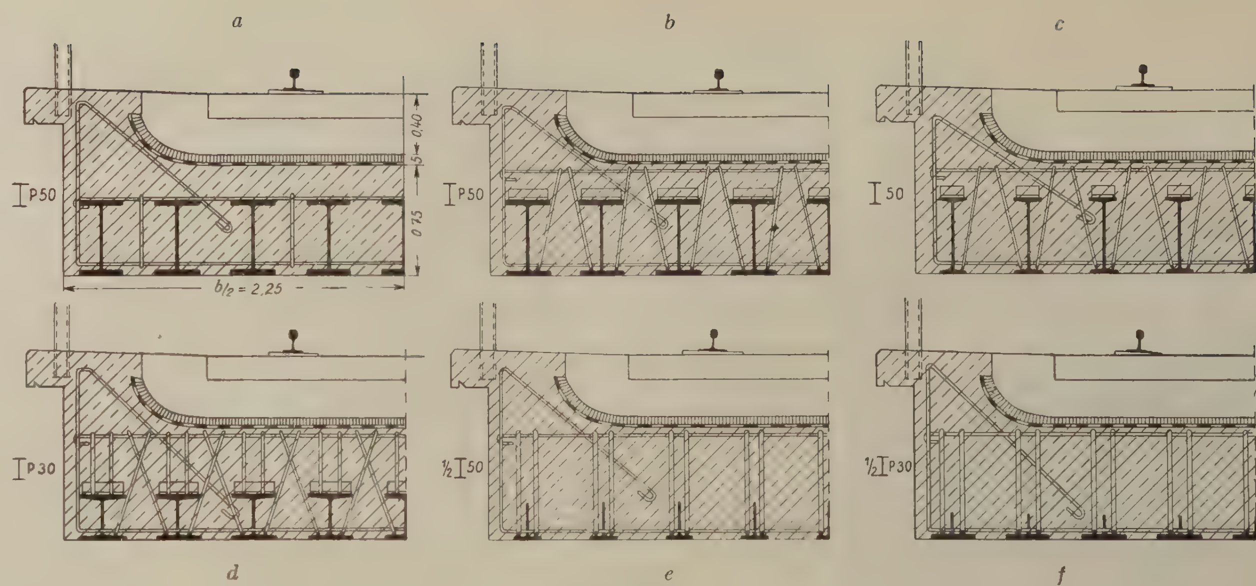


Fig. 1.

Table appendix to fig. 1.

Fig. No	Sections of the girders	Leverage arm of the internal forces h_s cm	Stress in the concrete σ_b kg/cm²	Stress in the steel σ_e kg/cm²	Saving of steel %
1*a*	I P 50	47	no bonding	1 230	0
1*b*	I P 50	50	87	870	0
1*c*	I 50	50	114	1 160	30
1*d*	I P 30	60	111	1 120	40
1*e*	1/2 I 50	66	92	890	50
1*f*	1/2 I P 30	67	107	1 360	70

= 870 kg/cm² for a permissible stress of $\sigma_{e\ zul.}$ = 1 400 kg/cm², or say only about 60 %.

Figure 1*c* shows the same section of concrete as figures 1*a* and 1*b*. In place of girders with wide flanges IP 50, standard sections I 50 were used. The stresses in both concrete and steel are more marked than in figure 1*b*. The steel section is reduced by 30 %; hence it is already more economical.

In figure 1*d*, IP 30 girders were used in place of IP 50. Thus the steel section was reduced by 40 % with respect to figures 1*a* and 1*b*. The stresses in the concrete and steel remain almost equal to those of figure 1*c*. A further saving of 10 % of steel in 1*d* with respect to 1*c* was only feasible because the centre of gravity of the steel section was lowered, as a result of which the leverage due to internal stresses was found to be increased from 50 to 60 cm (see col. 3 of the table for fig. 1). But even here with a consistent design, utilization of the material is still very unsatisfactory, because the component of the internal tensile stresses is applied at the centre of gravity, i. e. at the centre of the section of the girder and consequently the arm of the leverage of the internal stresses is relatively short compared with the conditions for flooring in ordinary ferro-concrete structures.

An additional static improvement can be secured by further lowering the centre of gravity of the steel section, which will increase the length of the leverage arm for the internal stresses. Since the rolling of girders with wide bottom flanges, or the addition of stiffening plates to the lower members would be very costly, girders cut through the middle have been adopted as shown in figures 1*e* and 1*f*. In this way, the steel section has been notably reduced and the leverage correspondingly increased.

By comparing figures 1*a* and 1*b* with figures 1*e* and 1*f*, it will be seen that one can save in all 50 % and even 70 % of steel by constructing flooring for bridges of embedded girders according to the composite system.

In designing ferro-concrete composite structures, one can use again, not merely old girders, discarded and freed from rust, but also metal beams built up of plates and sections taken from metal floorings, which in their form of metal floorings, do not comply with modern requirements in regard to the stationary loads they are required to support. By combining beams with a slab of precompressed concrete according to composite construction methods (after first removing the floor covering and the horizontal wind bracing), it is still possible to make good use of a considerable portion of the old structure (see fig. 2).

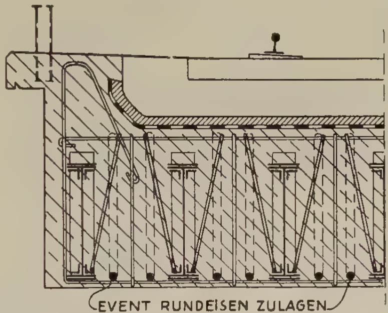


Fig. 2.

Event. Rundeisen Zulagen
= contingent addition of round steel bars

The embedded girders can more easily be dealt with nowadays in composite structures since numerous types of fixings have been studied and tested to assesss their holding capacity. The fixings in question should be of the simplest construction (fig. 3*a*) since the concrete will completely cover the girders. Simple and effective fixings are made by welding bent round irons to the flanges of the embedded girders similar to those used with reinforced concrete (see fig. 3*b*). The metal for these fixings is insignificant and can be obtained from crop ends, remainders or even from scrap.

The flooring of girders embedded in concrete but without fixings always show a considerable amount of calculable bending, the bottom flanges usually remain uncovered, in order to avoid cracks. In composite construction however, bending as with floors of reinforced concrete, is so slight that it is scarcely measurable. In composite reinforced concrete structures, one can protect the bottom flanges of the girders with a layer of concrete supported by 3 mm wire netting or by using expanded metal; by doing this it becomes unnecessary to give constant attention to the lower surfaces of the girders.

It has been confirmed that the composite construction method is greatly superior to the methods hitherto employed with the embedded girders. This superiority derives first of all from the utilization of the entire section of the concrete; it also results in a considerable saving of steel, which may be as high as 70 % and finally it makes it possible to deal with much longer spans. It is therefore better both technically and economically.

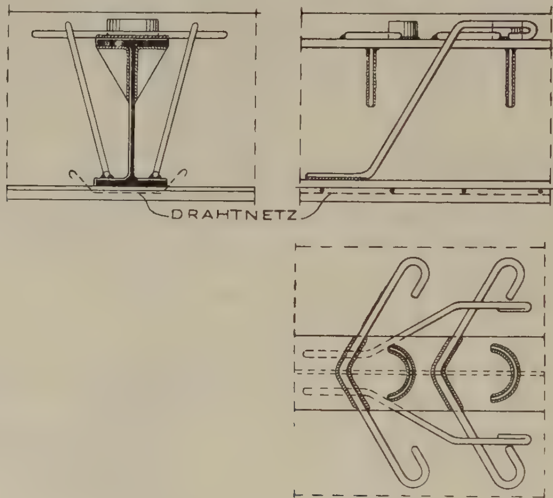


Fig. 3a.
Drahtnetz = wire netting

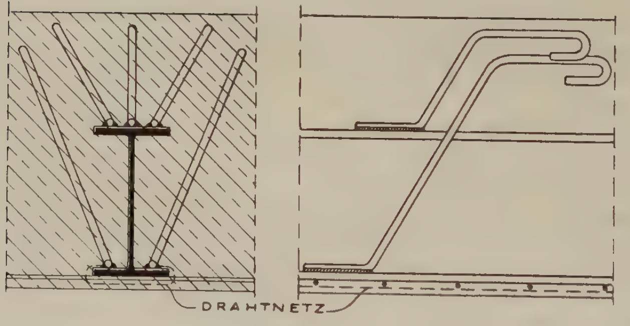


Fig. 3b.

[625 .14 (01 & 625 .172]

Certification of permanent way and track inspection trolley,

by Henri SCHMIDT,

Permanent way controller, Cologne.

(*Zeitschrift des Vereins Deutscher Eisenbahn Ingenieure*, No. 5, May 1951.)

I. Certification of track.

By certification of track is meant the verification of a new or relaid track having regard to the rules for construction and quality of work. Safety of operation and economic factors demand a conscientious execution of track certification. This is still carried out in different ways in the various Regions, as there are no standard instructions for carrying out these operations, although the Central Offices are at present engaged in formulating a standard code.

Certification for quality of work, which we propose to consider in this article, is of great importance, particularly as regards smooth running and economy, and comprises verification of transverse level, straight and curved alignment, seating of joints and packing.

Whilst inspection for observance of track construction regulations — gauge, joint spacing and positioning, sleeper spacing, correct and solid bedding of rails and fittings, quality of materials, section of ballast, drainage, etc. — is generally limited, except as regards rail gaps, to spot measurements and is therefore done rapidly, inspection of quality of work is much longer and takes much more labour.

Over an average Region, there is about 1 200 to 1 500 km of track to be relaid annually. Sections of running lines are certified by the Chief Engineer or his deputy, the District Engineer with the assistance of his section foremen and, where appropriate, the Contractor. The Chief Civil Engineer or Permanent Way Engineer may take part in the inspection; for important main lines, this is always so.

The operation requires eight to ten workmen. The date of the certification is fixed by the District Chief after collation and checking of the documents relating to preliminary acceptance, drawn up by the Chief of the section and stating that the track is ready for certification.

For this purpose, the different questions should be enumerated, generally in the form of a list; when certification is carefully carried out we arrive at a table which may contain as many as 45 columns. As the transverse level has to be taken every 5 m, about 200 lines are needed for 1 km of track. In any case, there is approximately 2 000 to 3 000 recordings per kilometre of track. This may be thought an over-elaboration, but it is easily explained when we consider that the cost of 1 km of new track, including materials and labour, is about 110 000 D. M., and that its life depends essentially on the *quality of the work*, which in turn is greatly influenced by the care taken in its certification.

The influence of certification on the quality of work has a considerable effect on the cost of maintenance (overhaul). In a Region of average size it runs to about 4 to 5 million D. M. per annum. If the work is perfectly done, economies can be achieved on this account, since it is possible to increase the interval between periodic overhauls.

However, certification is not confined to taking measurements and recording them in the tables. To give a clearer idea of the state of the track, we trace the levels on millimetre paper, to a 1/1 scale of heights and 1/1000 scale of lengths, particularly gradients and curves and the versines. This summary of the certification in the office of the section chief demands, as also does acceptance by the district chief, numerous staff and considerable times.

II. Track inspection trolley.

To reduce expense, following a certification of considerable duration, a machine was designed to measure and record in one operation the three elements which in certification demand most labour, viz., superelevation, direction and state of joints.

Figure 1 shews one of the trolleys used, fitted for track inspection and comprising the three measuring devices; it is known as the track inspection trolley (a patent is pending). The measuring equipment does not prevent its use for normal service. It can be arranged for measuring within two minutes; it is then run over the section of track to be inspected or certified. Measurements are recorded automatically on a paper roll, 210 mm wide, in different coloured inks.

Fig. 1. — Track recording trolley.

Figures 2 and 3 show extracts from the recording rolls, reduced to about 1/3 full size.

III. Arrangement and operation of measuring equipment.

a) *Measurement of superelevation.*

The DORPMÜLLER apparatus used for this purpose is well known and relies on the action of a heavy pendulum in the form of movement of a hanging bar when the vehicle frame is moved out of horizontal. The oscillating frame and the measuring panel are located in the rear box of the trolley (fig. 4). The whole of the recording equipment has been modified and modernised. The paper recording roll has been increased in width from 155 to 210 mm to cater for the measurement *b* and *c*. Particularly good results have been obtained by using Montblanc ball-pointed pens with blue, red and black ink. They give a clear and clean record and are

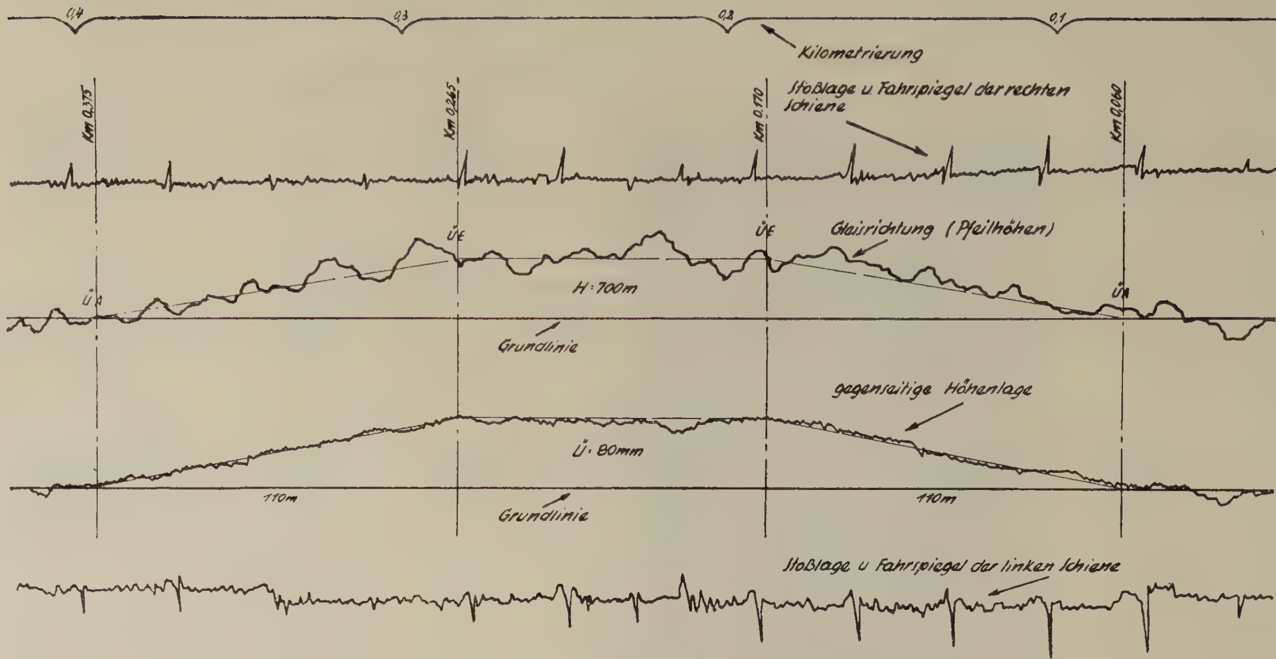


Fig. 2. — Extract from the diagram of a section of defective track.

Explanation of German terms:

Kilometrierung = mileage. — Stosslage und Fahrspiegel der rechten Schiene = state of joints and running surface of right-hand rail. — Gleisrichtung (Pfeilhöhen) = lay-out of track (versines). — Grund linie = reference line. — Gegenseitige Höhenlage = transverse level. — Ü = superelevation. — Stosslage und Fahrspiegel der linken Schiene = state of joints and running surface of left-hand rail. — **H** = radius.

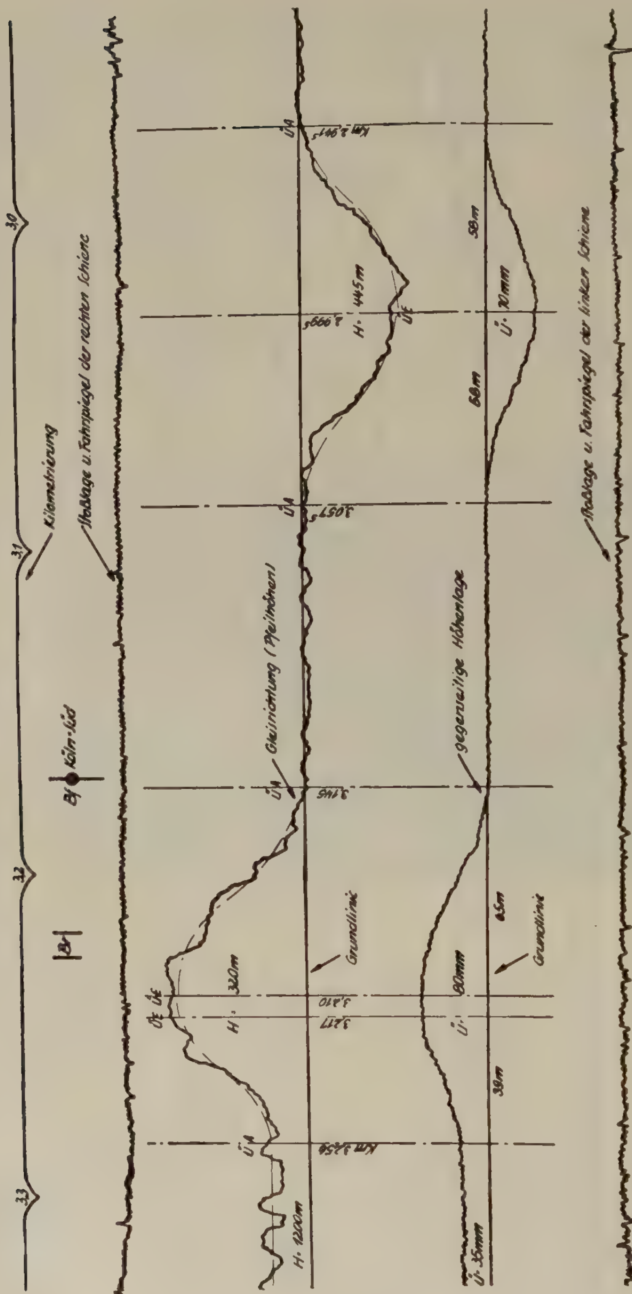


Fig. 3. — Extract from diagram of a fast line within town limits. Track well laid. To obtain the maximum speed, the short and sharp curves have compensated superelevation slopes.

always ready for service. They avoid the need for careful refilling, which was necessary with former types of pens. They are used in their normal commercial form and fitted in the writing apparatus by simply sliding them into cylindrical brass sleeves which serve as guides. The ink dries quickly, so that there is no need for blotting paper on the recording roll.

level of the two lines of rails, is recorded on a 1/4 scale. An adjustable recording device draws a reference line. Differences of the curve of level, in a different colour, of 0.5 mm are perceptible; they shew a transverse difference of 2 mm. The ratio of length scale, 1/1 000, to the height scale, 1/4, is very convenient and shews, in particular, any defects in the superelevation

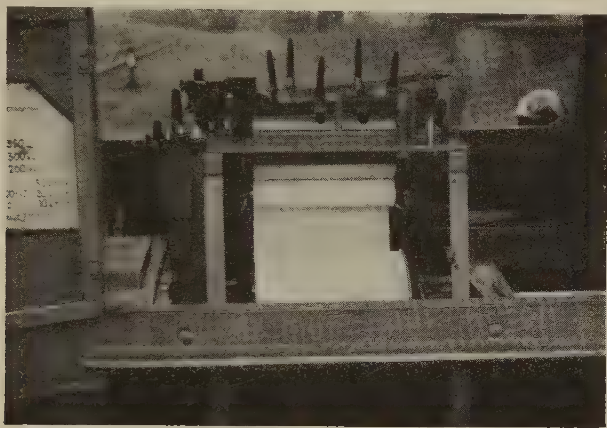


Fig. 4. — Superelevation measuring apparatus with the whole of the recorder gear.

The recorder is driven by the rear axle of the trolley through bevel pinions; engagement is made by a small lever. The reduction is arranged to give a length scale of 1/1 000, the former 1/666 scale of the Dorpmüller apparatus having shewn itself impractical since it prolonged the gradients, and defects were not sufficiently clearly shewn. An additional advantage is that a scale of 1/1 000 simplifies interpretation.

Distance is recorded automatically on the roll every 100 m or 10 cm of paper.

In order that the trolley may fulfil its double function of vehicle and recording trolley, it is necessary to provide wheels with cylindrical tyres and to short-circuit, or block the suspension springs.

Superelevation, that is, the difference in slope. Figure 5 shews a good and a bad transverse profile.

b) *Alignment measuring.*

A good alignment, particularly on curves, is absolutely essential for safety, smooth running and conservation of track and rolling stock. Versines can be checked by measuring with a wire or an optical measurer. This operation requires at least three men. The versines, measured every 5 or 10 m are related to the ordinates on a scale of 1/1 on millimetre paper (length scale 1/1 000), connected together to give a versine diagram, which alone allows the curve to be checked, the important point being the difference between consecutive versines rather than the difference between

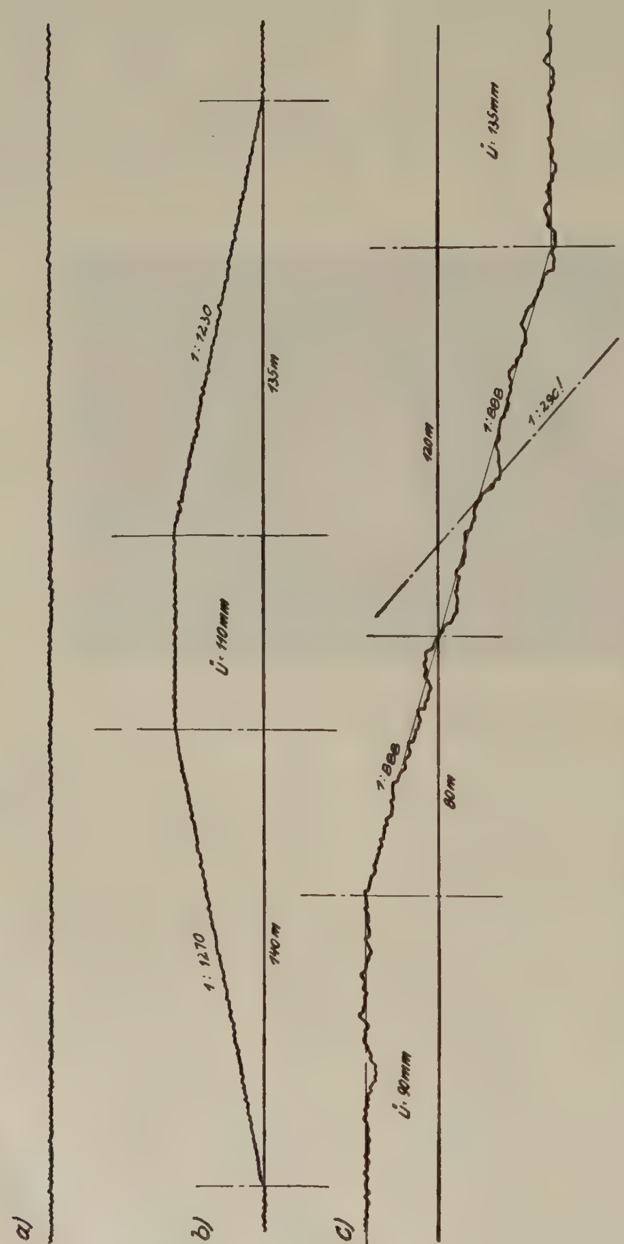


Fig. 5. — *a*) good transverse level and alignment;
b) good gradient diagram on a right-hand curve;
c) bad gradient curve of two reverse curves with no intermediate straight section.

measured and theoretical lengths of versine (*).

On the track inspection trolley, these measurements are made with a newly-designed versine measurer. Figure 6 shews the sine diagram is recorded automatically on a 1/1 scale; a magnifying arrangement can be brought into effect to give a 2/1 scale. Contrary to the previous hand-operated apparatus and wire measurer which gave

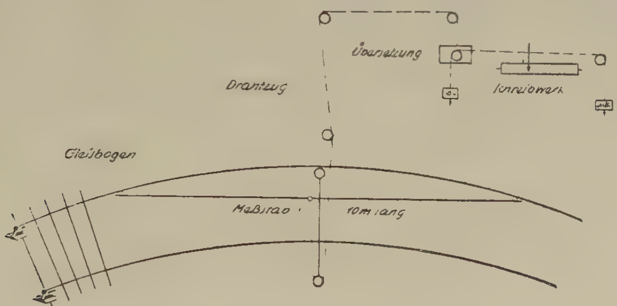


Fig. 6. — Sketch shewing principle of versine measurer.

Explanation of German terms:

Gleisbogen = curve. — Massstab 10 m lang = rule 10 m long. — Drahtzug = transmission wire. — Übersetzung = multiplication arrangement. — Schreibwerk = recording gear.

Fig. 7. — Track measuring trolley, prepared for recording.

principle of this device and figure 7 shews its practical application. It comprises, in essence, a measuring bar 10 m long, serving as a chord, a transmission and a recorder. When running through a curve, the ver- versines every 5 or 10 m, it shews the actual variation of curvature *at each point*.

Comparative measurement of a badly-aligned curve, shewn in figure 8, illustrates very clearly the agreement between the record by the trolley and the manual measurement noted above.

(*) See SCHRAMM: *Der Gleisbogen*, chapt. VII.

In general, it is nowadays considered that a curve is well-aligned when the difference in length of two successive versines, with a chord of 10 m does not exceed 3 mm. In addition, for the same length of chord (10 m) the difference in length of two successive versines should not be more than about $\frac{2\,500 \text{ mm}}{4 \text{ V}}$ in a poor curve (V being the speed in kilometre/hour), otherwise it is necessary to rectify the alignment or to reduce the speed.

This is a very severe condition in practice and therefore to what degree it is possible to modify this rule, particularly for old track, is under consideration at present.

It may still be considered a special advantage of the track recording trolley that the two recordings, which apply to safety and smoothness of running, the superelevation and the versines, which must be proportional in their presentation, are measured at the same time, one above the other. In effect, if contradictory defects appear at the same point on the two diagrams it can easily be seen that this is a dangerous point.

c) *Rail joint recording apparatus.*

One of the elements of the track which occasions the most care is the rail joint, as particular attention and considerable expense are necessary for its establishment and maintenance in such a condition that it causes no shock. On new track it can be constructed so that, neither in running nor in recording can any difference be noted between it and a jointless track. To arrive at this, it is necessary when laying new track, or relaying, that the joint should be given a superelevation of about 1 - 2 mm, since under the influence of shock, which it is impossible to eliminate entirely, there is a greater compression of the ballast than under neighbouring sleepers. It is, however, necessary to avoid from the start any drop at the joint, because this is the origin of all troubles, the wheel no longer run-

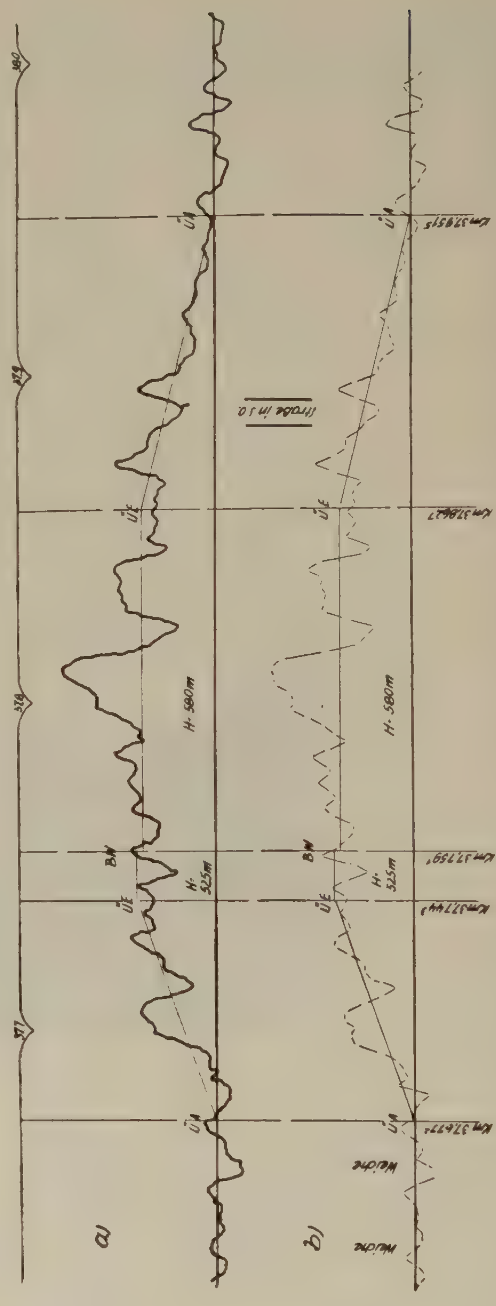


Fig. 8. — Versine diagram of a defective curve, shewn for comparison with : *a*) the trolley; *b*) manual theoretical specification.

ning over a joint, but really leaping over. As a result of the combination of bound, shock and drop in height the ballast eventually becomes so packed that it acts almost as an anvil. The sort of impression given by running over such joints is well-known. The number is unfortunately high, the of joints, it is necessary to set at each joint a metal rule, 1.5 m long and verify the position with feeler gauges, entering the results on the certification documents, which represents 132 measurements and records per kilometre of track with 15 m rails.

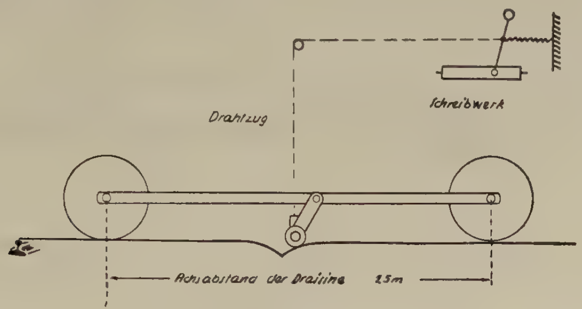


Fig. 9. — Sketch shewing the principle of the joint measurer.

N. B. — Achsabstand der Draisine = wheelbase of the trolley. — Drahtzug = transmission wire. — Schreibwerk = recording gear.

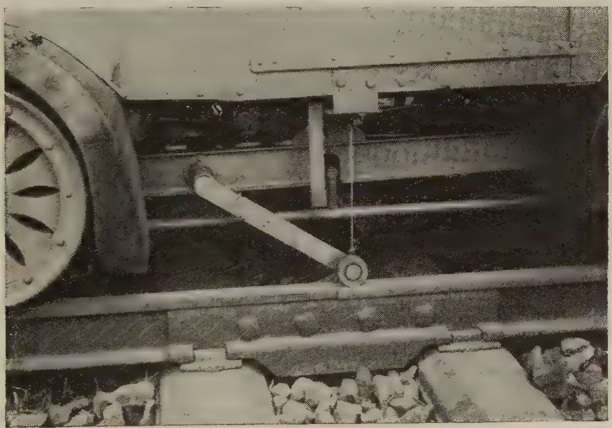


Fig. 10. — Joint measuring device.

result of maintenance which has for 15 years been neglected for reasons which we all know. In view of the vulnerability of rail joints, the standard of their bedding must be watched with particular care when track is certified. To verify the position

To carry out this work in a modern manner, a rail joint recording apparatus has been mounted on the trolley, which automatically registers the position of joints in each line of rails at the same time as the information in *a*) and *b*). Figure 9

is a sketch shewing the principle of the apparatus and figure 10 its practical application. It comprises a cross-bearer, resting on the two axles of the trolley, a sensitive roller mounted on the middle of the cross-bearer, applied by spring pressure and movable in a vertical direction, a wire transmission and a recorder.

sufficient to note that a joint is dropped, because a badly packed joint is always low.

Hammer testing of sleepers to test packing is not eliminated, but it can be reduced to spot checks if recording shews a perfect level, which can only be obtained with good packing.

Figure 11 shews several extracts from

Fig. 11. — Illustration of state of joints, alignment of inner edge of rails and running surface of rails : *a*) position of joints and general defective state; *b*) generally good state of joints after 10 years' service; *c*) good joints in a new rail.

Explanation of German terms:

Rechte Schiene = right hand rail. — Eingeschlagener Stoss = dropped joint. — Spitzer Stoss = raised joint. — Linke Schiene = left hand rail. — Grober Fehler in der Fahrkantenflucht und Fahrspiegelunebenheiten = major defect in alignment of inner edge of rail and inequalities in running surface.

When running on track, all unevennesses in the running surface of the rails, dropped or raised joints, inequalities in the running surfaces and alignment of the inner faces of the rails are magnified and recorded.

These measurements can obviously not replace the state of the joints recorded under load by means of large track-recording vehicles, but they give a very similar result. During track certification, it is records of joint measurement with the track recording trolley. Because of the high sensitivity of the measuring device and the 2/1 scale of transmission, the slightest irregularities in the running surface are recorded. Bad welding can thus be seen on the graph, defects in rails, kinks, and small irregularities in the alignment of the guiding edge of rails of 1 mm or more are also clearly shewn.

IV. Summary.

This article commenced by shewing the particular importance of a very careful certification of the track and its influence on the quality of the work carried out, and consequently on the cost of track maintenance. To bring certification more up-to-date, a track recording trolley was designed, which in one operation records :

1) the transverse level of the track, in the form of a graph of superelevation or gradient;

2) versines, in the form of a versine diagram;

3) the state of the joints and the alignment of the inner edge of the rails; on a paper roll at a rate of about 12 minutes per kilometre. Apart from the economy in time and labour for the measurements and its practical consequences so far, the much more logical and clear recording of the results of the certification on the measuring roll stimulates the self-respect of the workers and gangs in the direction of better work.

[**621** .431 .72 (42)]

The Fell locomotive of British Railways.

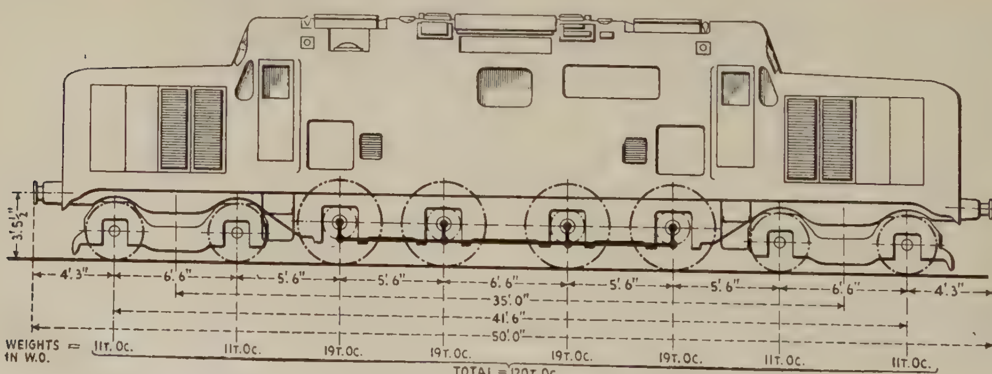
A four-engine main-line unit of 2 000 HP with new form of engine loading and mechanical transmission.

(Diesel Railway Traction, July, 1951.*)*

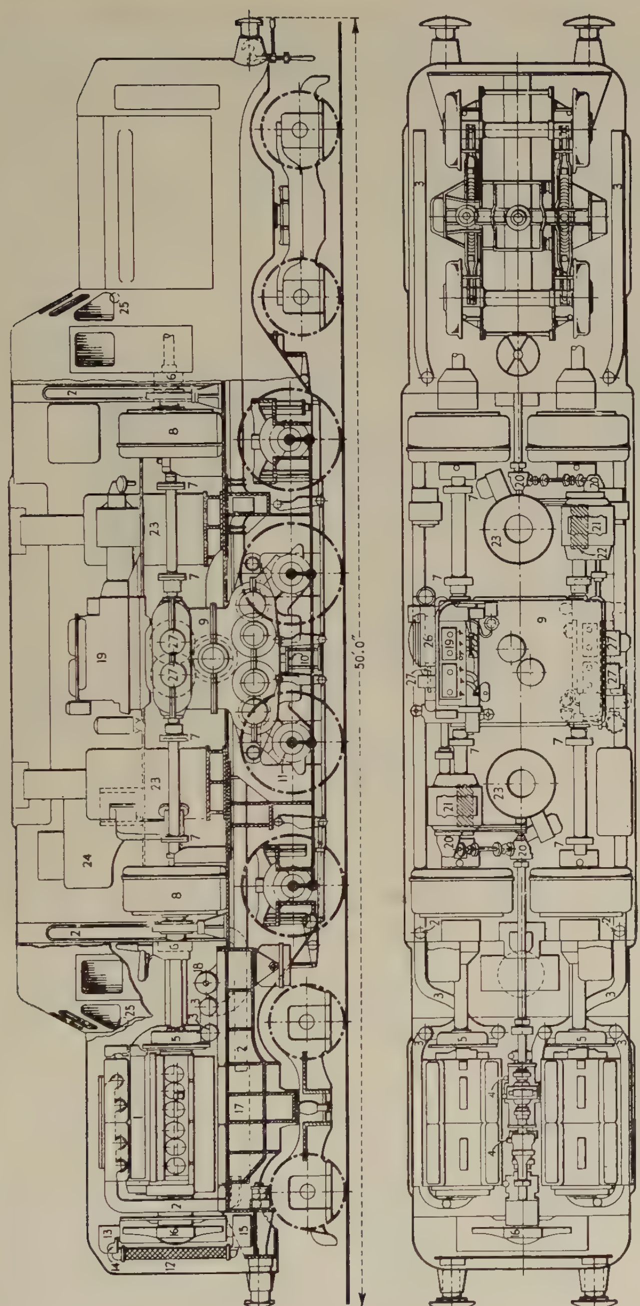
For some months past the so-called Fell Diesel-mechanical locomotive of 2 000 HP, known to be under construction at the Derby Locomotive Works of the London Midland Region, British Railways, has evoked considerable interest in this country and abroad, not merely because of its power in relation to mechanical drive, but because it was known that new principles in such a drive were being embodied.

This locomotive, No. 10100, has been running experimentally in the Derby area for several months, and was also on view at Marylebone Station, London, on May 23. The principles of its power and drive were originated by Lt.-Colonel L. F. R. Fell,

British Railways main-line Diesel-mechanical locomotive No. 10100.



Principal dimensions and weights of the Fell locomotive.

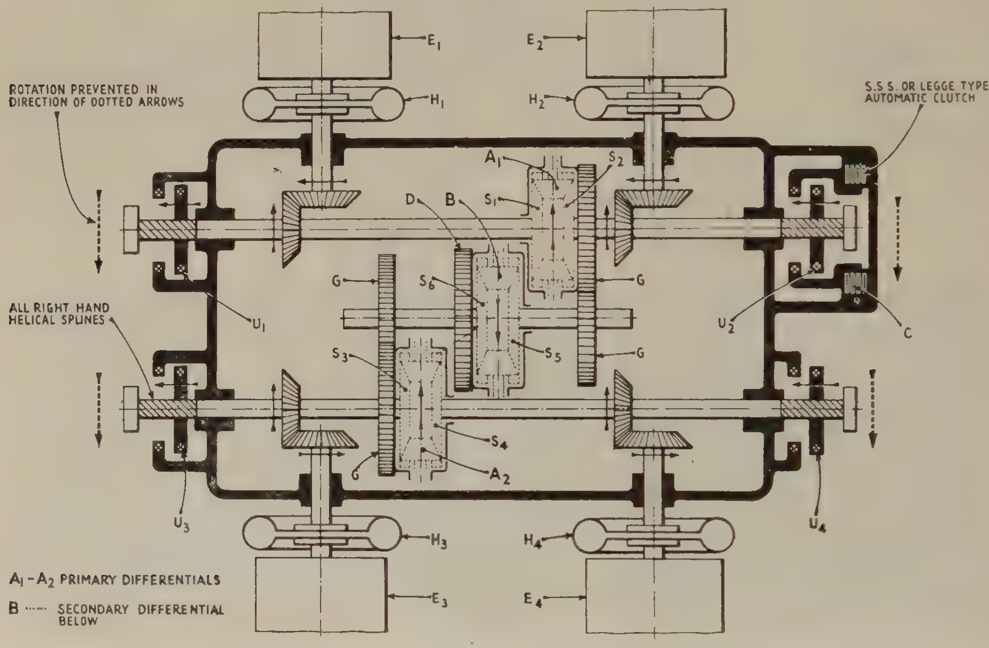


1. 500 HP Paxman 12 RPH engines.
2. Exhaust pipes for 12 RPH engines.
3. Supercharge air pipes for Paxman engines.
4. Water circulating pumps.
5. Bibby couplings.
6 and 7. Layrub couplings.
8. Fluid couplings (Type S. C. R. 5, Size 36).
9. Gearbox.
10. Reversing connection.
11. Quill driving shaft.
12. Radiators (water elements : oil elements).
13. Water header tanks.
14. Oil top manifold.
15. Bottom tanks.
16. Radiator fan.
17. Diesel oil fuel tanks (capacity 720 gal.).
18. Lifting brackets.
19. 150-HP A. E. C. Diesel auxiliary engines.
20. Bevel gearboxes for auxiliary shaft drive.
21. Holmes-Connersville supercharge blowers.
22. Vacuum exhausters.
23. Train heating boilers.
24. Train heating boiler water tanks (capacity 500 gal.).
25. Locomotive controls.
26. Clutch to release abutment of one S. S. S. coupling.
27. Synchro self-shifting couplings.

Equipment layout of Fell Diesel-mechanical locomotive No. 10100.

and were developed by Fell Developments Limited, the locomotive itself being the responsibility of Mr. H. G. IVATT, Chief Mechanical Engineer, London Midland Region.

Basic principles involved were: (*a*) the use of a number of main propelling oil engines; (*b*) the ability to bring in and cut out these engines one by one; (*c*) the pressure-charging of these engines by separate sets arranged to give high charging pressure at low main engine r.p.m.; and (*d*) the use of only one main gearbox, taking the drive from all the propelling engines.



The principle of the Fell arrangement of four engines with differential drive to one gearbox; the final drive through quills to the wheels is not shown.

The use of a number of main propelling engines having the required torque characteristics was considered by the builders to have the following advantages:

1. increased dependability, as the locomotive can proceed at reduced speed even if all but one of the main engines are out of action;

2. the individual engines can be of a higher-speed type and therefore lighter and more compact;

3. as a consequence of 2, the engines themselves and their component parts are, for a given power, lighter, and therefore more easily and more rapidly handled for replacement or repairs.

As the transmission employed is purely mechanical, an essential feature of the Fell system is that the main engines shall, for the purpose of starting the train and for ascending steep grades, be capable of developing high torques at low rotational speeds. To achieve this result the engines are relatively highly pressure-charged at their lowest speeds and progressively less highly pressure-charged as their speed rises. It is therefore necessary that the engines

used shall have a good response to pressure-charging so as to economise air, and be of a type in which high charging at low speeds does not give rise to unduly high cylinder pressures.

In order that the required pressure-charge, involving the supply of large volumes of air, may be available when the main engines themselves are running at low speeds, the air blowers of the displacement type are separately driven by auxiliary engines — in the case of No. 10100 by Diesels which are themselves pressure-charged off the same air supply to reduce their size and weight.

These auxiliary engines are provided with variable-speed governors, which are in turn influenced by the air-charging pressure, so that a fall in this pressure automatically causes the auxiliary engines to speed up in an endeavour to maintain the air pressure. The capacity of the blowers, however, and the maximum speed to which these engines are permitted to run, are such that very early in the speed range of the main propelling engines the charging pressure commences to fall, and continues to fall progressively as the speed of the main engines increases, so that at the highest speed of the main engines the pressure-charge has practically reached zero. The governors on the main engines limit the fuel supplied in relation to the available air charge and the engine speed. The decrease in charging pressure with speed, taken in conjunction with the limitation of fuel by the governor, is claimed to result in the main engines developing approximately constant horsepower over their speed range.

Transmission principles.

For the purpose of connecting and disconnecting individual engines and the common mechanical transmission, each engine is provided with a hydraulic coupling of the scoop-control variable-filling type. This common mechanical transmission referred to involves the use of differential gears as the means of grouping together the output of a number of propelling engines.

In the case of four propelling engines, as in locomotive No. 10100, the transmission uses three differential gears so arranged that two, A_1 and A_2, act as primary differentials, and the third, B, as a secondary differential. Each engine E_1, E_2, E_3, and E_4, is connected through its hydraulic coupling, H_1, H_2, H_3, and H_4, to one of the four sun wheels of the primary differentials. The planet carriers of the two primary differentials are connected by gears G G, one to each of the sun wheels S_5 and S_6 of the secondary differential, and the planet carrier of this last differential delivers the combined power of all the engines to the road wheels through a train of gears, D, and a final reduction drive. The gears of the reversing train are in constant mesh and by means of a novel arrangement the direction of locomotive travel can be altered.

By using differentials in this manner a progressively changing speed ratio is provided without the use of change-speed gears involving a series of stepped ratios; furthermore, inherent coupling slip is minimised. This feature will be apparent on considering the events which take place when starting up the train and progressively bringing all four engines into action to propel the train.

Assume all four engines to be running idle with their hydraulic couplings empty. Then, on opening the regulator and at the same time allowing one of the couplings, say H_1, to fill, the associated engine, E_1, will commence to drive the sun wheel S_1, to which the output side of that coupling is connected. Each of the four primary sun wheels, S_1, S_2, S_3, and S_4, has associated with it a uni-directional device, U, which prevents any backward rotation of that sun wheel.

It will be appreciated that as a result of driving one of the sun wheels, say S_1, in a forward direction, and of preventing backward rotation of the other sun wheel,

S_2, of that primary differential by means of the uni-directional device U_2, the planet carrier of that differential will drive the sun wheel, S_5, of the secondary differential, B, to which it is connected through the gears G G, and so transmit the driving torque of the connected engine E_1, to the road wheels *via* the gear, D. This engine, E_1, will thus be coupled to the final drive and road wheels with a superimposed gear reduction ratio of four to one, namely, two to one due to its primary differential A_1 and two to one due to the secondary differential B.

When the train has reached a suitable speed, the coupling H_2 of the second engine, E_2, associated with the other sun wheel, S_2, of the primary differential A_1 is allowed to fill, and the output of this engine is increased by its governor until the torque which it is developing exceeds the backward torque on its sun wheel, S_2, which is equal to that of E_1, the first engine engaged. As soon as this condition occurs, the sun wheel S_2 of this second engine moves in a forward direction, and its rotational speed is added to the rotational speed of the sun wheel S_1 which is already running. This results in an increased speed of the planet carrier of A_1 and so of the road wheels.

In a similar way the remaining engines, E_3 and E_4, are in turn brought into action, and it will be seen that the speed ratio between the engines and the road wheels, when the connected engines have attained the same rotational speed, will be four to one for the first engine E_1, two to one for the second engine E_2, one and one-third to one for the third engine E_3 and one to one for the fourth engine E_4.

The uni-directional devices, U, are of the Legge or S. S. S. type, in which a castellated sliding member is caused to move axially along its shaft by inclined splines. Any tendency of the shaft to rotate in a backward direction causes the sliding member to move axially to engage a stationary castellated member, thus locking the shaft against backward rotation.

With a device of this nature on each sun-wheel shaft, any attempt to push the locomotive in a backward direction will result in all the devices U becoming operative. It follows that if, during buffing operations, the buffer springs of the train become compressed when the engine backs up to the train, it might be impossible to operate the reversing lever owing to load on the gear teeth due to the expansion of the buffer springs. To meet this condition one of the devices U (for example U_2) is arranged so that its stationary member is connected to the gearbox structure through a suitable clutch, C, which may be released to free the transmission. In locomotive No. 10100 this clutch is held « in » by a vacuum cylinder so that the transmission is free with no vacuum.

A feature claimed for this transmission is that the changing speed ratios are passed through without shock by finger operation of triggers, permitting the hydraulic couplings H to fill in turn with the regulator held in the maximum power position until all four engines are on load and running at the same speed. After this condition has been reached the regulator is manipulated as required to give the desired train speed with all four engines in operation.

Maximum tractive effort can be developed when only a single engine is propelling the train, and the bringing into action of the remaining engines permits the train speed to be increased. Consequently any route within the capacity of the locomotive when all the engines are available could be completed (at reduced speed) even if only one engine remained effective.

Final drives.

The lower section of the gearbox contains the final-drive train of gears and the reversing mechanism, the latter consisting of a pair of sliding dog clutches, one of which is engaged at a time according to the direction in which it is desired to run the locomotive. A warning light indicates that the sliding dog clutch is fully engaged

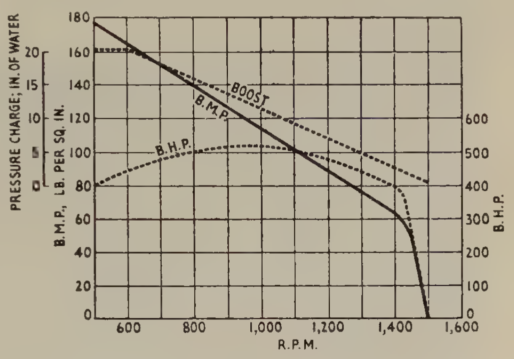
in the direction in which the locomotive is required to move, *i. e.*, foregear or backgear. From the reversing shafts, the final drive is through two hollow quills, running in white-metal bearings at each end of the bottom section of the gearbox and integral with it.

The quills are mounted on the two intermediate driving axles with sufficient clearance above and below the axle to allow for full freedom for rise and fall relative to the frames, and at each end carry arms which transmit the torque to the respective wheel through flexible rubber units between the wheel spokes. Lubrication of the gearbox is by two external oil pumps driven by the auxiliary engines. The outer and driving wheels are coupled together throughout by coupling rods, with pin joints, of the type used on conventional steam locomotives.

Engine equipment.

In the Fell locomotive four Paxman 12 RPH main engines are arranged in pairs at the ends. Each has 12 cylinders 7 in. bore by 7 3/4 in. stroke and operates over a speed range from 500 to 1 500 r.p.m. Nominal top output of each is 500 b.h.p. at maximum rotational speed. The equipment layout of the complete locomotive is shown on p. 687.

Supplementing these are two A. E. C.-Ricardo A 210 D engines operating over a speed range of 1 300 to 1 800 r.p.m. Each of these engines drives directly a Holmes-Connersville Roots-type blower which pressure-charges two of the main Paxman engines; and each is itself pressure-charged from the same air system and to the same charging pressure as the main engines. Variation of the charging pressure, b.m.p., and b.h.p. of one main engine, plotted over the rotational speed range, is shown in the graph below. So as to limit the power output at any given engine speed to the predetermined value for that speed, a device is provided which is, in effect, an adjustable limit on the fuel pump rack, and which is under the control of a suitable centrifugal governor. To this end each main engine is provided with a special centrifugal governor which, through hydraulic servo-mechanism, controls the angular position of a cam. This, in turn, limits the power output to the characteristics. Move-



Performance characteristics — one main engine.

ment of the driving regulator controls the power output of the engines within these limits by operating a pendulum lever in each governor.

The pin on which the pendulum lever swings can be displaced by a vacuum-actuated diaphragm in opposition to a spring in such a manner that when it is displaced in one direction by the pull of the diaphragm, movements of the driving regulator can give the engine any quantity of fuel up to the maximum permitted by the cam. Release of vacuum allows the spring to move the pendulum lever suspension in the opposite direction so that the engine receives only idling fuel irrespective of any movements of the regulator.

Each main engine crankshaft is provided with a Wellman Bibby coupling carrying on its output member a shaft which conveys the torque to a Layrub coupling mounted on the input side of a Vulcan-Sinclair hydraulic coupling. This coupling is of the scoop-control variable-filling type, size 36, and its output side is connected by a shaft with one of the four input shafts of

the gearbox. This latter shaft also has been fitted with Layrub universal joints at both ends.

All controls of the main engines and of the transmission employ vacuum as the actuating means, with the single exception that the coupling together of the regulator movements between the ends of the locomotive is effected mechanically by a longitudinal rotatable shaft.

Auxiliary sets.

The auxiliary engines are provided with variable-speed governors, and a control device influenced by the charging air pressure is directly connected to the governor speed lever so that when the air pressure falls the engine is speeded up, and *vice versa*. Springloaded blow-off valves are provided on the air trunking to limit the pressure charge to the desired value of 10 lb. per in. To avoid unnecessary blower work when the locomotive is at rest with auxiliary engines and, consequently, the blowers running, these blow-off valves are so arranged that during such periods when pressure-charge is not required the air has a free escape to atmosphere. When charging is required, vacuum is applied to a diaphragm which causes the blow-off valves to operate as springloaded valves.

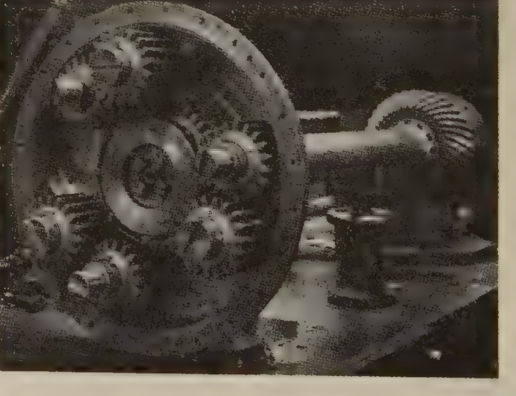
On the air trunking there are also provided inwardly-opening automatic valves for the purpose of enabling the two main engines associated with the trunking to run as naturally-aspirated engines in the event of any failure of the pressure air supply. The air delivered by the blowers passes directly into water-cooled after-coolers on its way to the engines. The water for these coolers is pumped through roof radiators and forms a circuit independent from the engine-cooling system.

Cooling system.

The jacket water of all the engines is cooled by gilled-tube Serck radiators placed at the extreme ends of the locomotive. One pair of main engines and one auxiliary engine are coupled to one radiator.

In order to hasten the warming up of the main engines in cold conditions the water circuit is arranged so that the auxiliary engine associated with a pair of main engines discharges its hot jacket water into the jackets of this pair. A part of each main radiator is devoted to cooling the main engine lubricating oil which is circulated from the engine sumps to the radiators by low-pressure pumps in the sumps of the main engines. Each auxiliary engine has a water-cooled lubricating oil cooler mounted on the engine.

When pulling a train the rear radiator is less favourably placed as regards cooling air than the forward radiator. The water circuits have therefore been arranged so that the auxiliary engine associated with the pair of main engines at one end of the locomotive draws its water supply from the bottom of the radiator at the other end of the locomotive. The jackets of the auxiliary engines are connected to an equalising pipe at roof level. With this arrangement there is a continuous but limited interchange of water between the rear and forward radiators which serves the purpose of equalising the temperatures of these radiators.

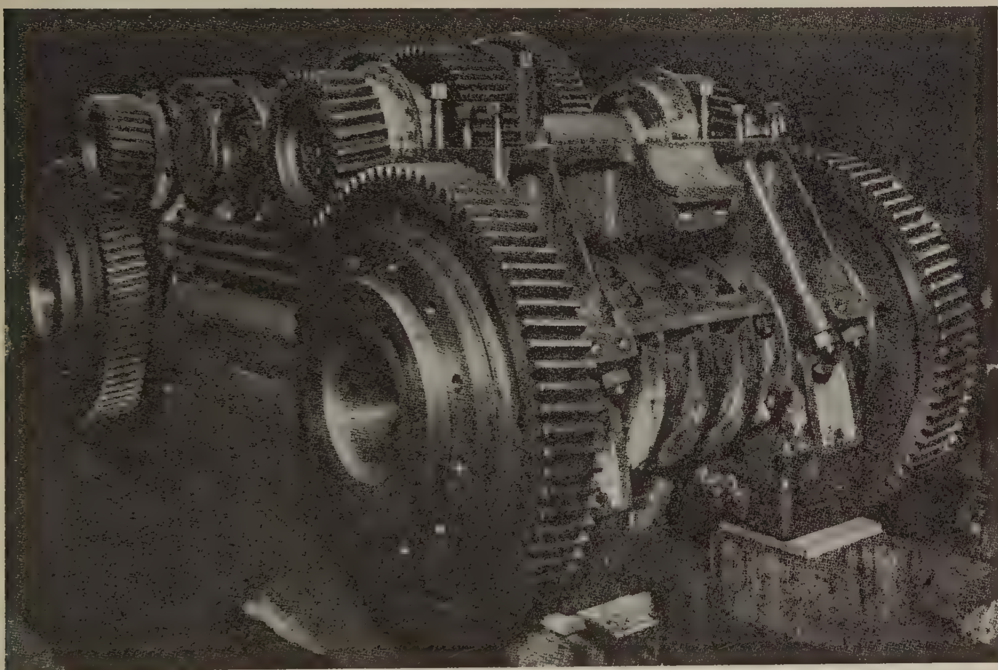


One half of the primary differential casing with sun and planet wheel assembled.

Auxiliary equipment.

The fans for cooling the main radiators are rotated by shafting driven by the auxiliary engines. Power is taken from the end of one of the rotor spindles of each blower and thence by two pairs of bevels to shafting running fore and aft down the centre line of the locomotive. The shafts each drive a Westinghouse type 3V.72 exhauster and a pair of centrifugal pumps which draw from the bottom of one of the radiators and deliver to the main engines between which they are placed. Means are provided to prime the main engine lubricating systems and ensure servo-oil for the functioning of the governors immediately on starting up. All the engines are started electrically on a 24 V circuit from batteries charged by 1 300 W generators on the auxiliary engines.

The gearbox is lubricated by a system of feeds and jets supplied with oil drawn from the sump of the box by two Rolex pumps. Direct radiation from the surfaces of the gearbox is relied on for cooling the lubricating oil.



Assembly of the final drive wheel and pinion engagement, showing also the cannon bearing and quill shafts which surround the two driving axles.

Driving controls.

The controls in the driving cabs comprise a row of four small levers, a regulator, and a forward-reverse lever. The four small levers actuate vacuum valves to enable vacuum to be applied to, or released from, diaphragm cylinders each controlling the scoop of one of the hydraulic couplings. The vacuum valve also controls the application of vacuum to the diaphragm on the

governor of that particular engine to permit the regulator movement to give more than idling fuel.

Assuming the two auxiliary engines and all four main engines to be idling, and that it is desired to start the locomotive into motion, the driver :

1. moves the regulator through the early part of its travel. In addition to setting the governor to permit load to be taken, this puts vacuum on to a diaphragm which loads the clutch on the uni-directional coupling, and also puts vacuum on the blow-off valves and on to the governors of the auxiliary engines;

2. pulls over one of the four levers; this, by vacuum, puts in the scoop of the hydraulic coupling of its associated engine, and also puts vacuum on the diaphragm of the governor of the same main engine to permit the governor to give the fuel represented by the regulator setting;

3. engages other engines in a similar manner to obtain predetermined locomotive speeds. The following speed limits comprise the driving instructions in the case of locomotive No. 10100 and apply when either ascending or descending in the speed range :

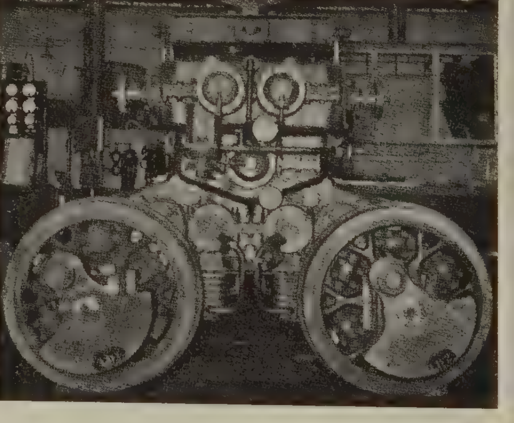
First engine	0-6 m.p.h.
Two engines	6-17 m.p.h.
Three engines	17-24 m.p.h.
Four engines	24-78 m.p.h.

The regulator control is so arranged that the engine continues to idle when the main regulator is open, if the fluid coupling is not engaged, until called on to drive the locomotive. For shunting work, the driver can operate the locomotive at full torque on one engine only, cutting in the others as required when changing over from shunting to the main line.

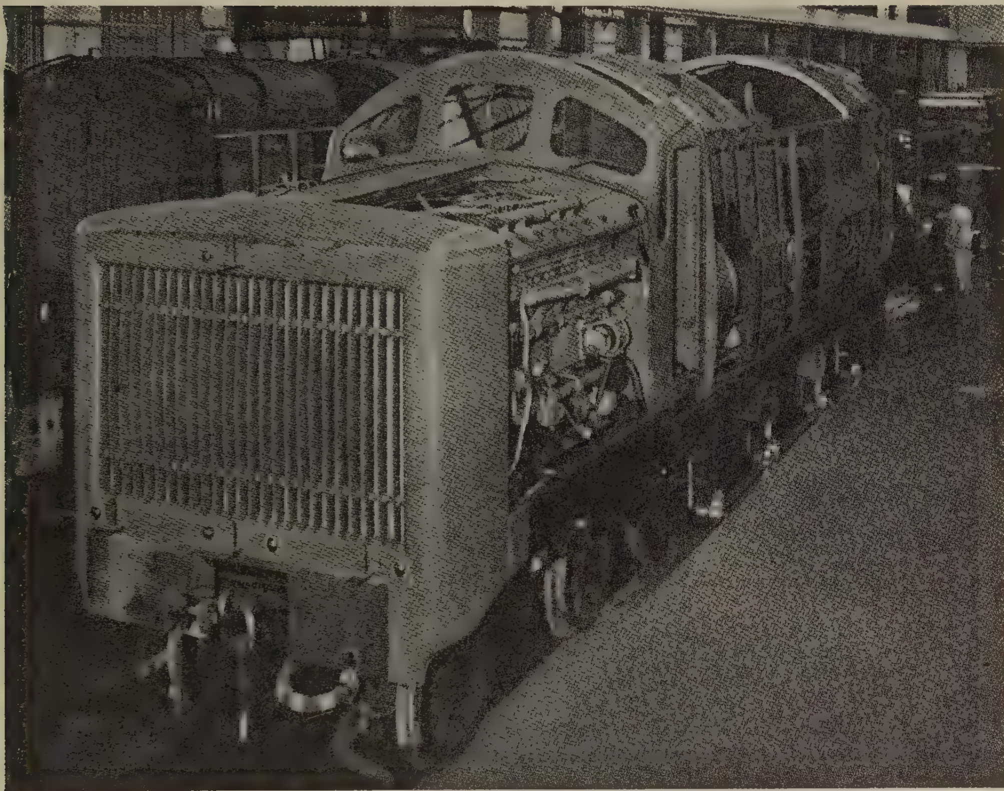
When shutting down, the final movement of the main regulator handle replaces all starting levers in the « stop » position. To reduce speed, the regulator is shut down only to a point where it is checked by engaging with the starting levers, thus maintaining whatever position the latter were set to, when the regulator is re-opened. The two-position reverse lever marked « forward » and « backward » is at the right hand. It is mechanically interlocked with the regulator so that it can only be altered in position when the latter is shut right down. All vacuum controls can be isolated at either end by a master cut-out valve.

Mechanical portion.

The mechanical construction is based on the 2-D-2 wheel arrangement, with a plate-frame structure of the conventional type, except that the fuel tanks are an integral part of the frame structure above the bogie centre pivots. Pumps transfer the fuel from these tanks, which have a combined capacity of 720 gal., to service tanks for engines and train-heating boilers. All driving and coupled axleboxes are of Timken roller-bearing pattern with independent laminated springs having rubber auxiliaries on the hangers. The bogies are of standard bolster type with 3 ft. dia. wheels and compensated laminated springs in cradles. The coupled wheels are 51 in. dia., and the transmission gear ratios per-



Gearbox and quills mounted on driving wheels after final checking of cranks and gear wheels, showing the Goodyear rubber driving blocks cushioning the drive between quill and wheel.



Works view of locomotive, showing wheels, cabs, housings, and a portion of the roof in position.

mit of a top speed of 78 m.p.h. Gravity sanding is fitted to the outer coupled wheels.

Equipment installed includes two train-heating boilers with Laidlaw Drew automatic oil burners. The feed water is preheated by the main Diesel exhausts, the gases passing through tubular heaters situated outside the main frames adjacent to the bogies. Boiler water tanks aggregating 500 gal. capacity are carried, and can be replenished from water tanks *en route* by a small water pick-up scoop.

Vacuum brakes of normal type are fitted, with hand brakes operating in conjunction; but as no blocks are fitted to the bogie wheels, the braking power is equivalent to only 48 % of the locomotive weight. The vacuum brake valve is mounted by the driver's right hand, and an instrument panel carries locomotive speed and engine r.p.m. indicators, together with oil pressure gauges, engine starting switches, and the like equipment.

The principal dimensions and other particulars of the Fell locomotive are:

Gauge	4 ft. 8 1/2 in.
Length over buffers	50 ft.
Height	13 ft.
Overall width	9 ft.
Total wheelbase	41 ft. 6 in.
Bogie wheelbase	6 ft. 6 in.
Wheel diameter	4 ft. 3 in.
Weight in working order . .	120 tons
Gear ratio (with four engines).	2.9067/1
Maximum tractive effort . .	25 000 lb.
Maximum locomotive speed .	78 m.p.h.
Engine fuel capacity	720 gal.
Total auxiliary engine b.h.p.	300

[621 .135 .2]

Flame-hardening of locomotive tyres.

(From *The Railway Gazette*, April 4, 1952.)

For many years experiments have been carried out with a view to reducing the wear on locomotive tyres, and any means by which this can be accomplished is worthy of consideration, particularly in view of the need to conserve steel. When excessive wear takes place in the root of the flange due to operation over sections of line hav-

Soft flange.

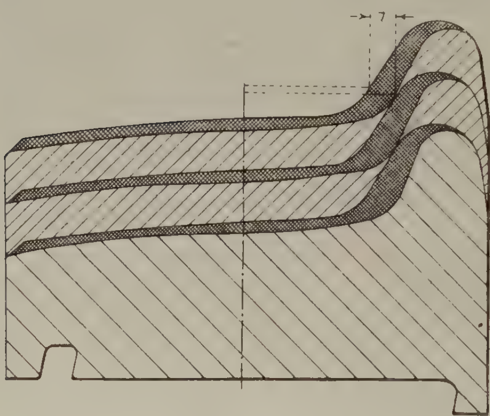


Fig. 1. — Rapid wear on line having great number of curves.

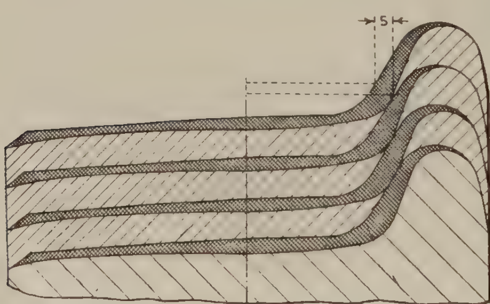


Fig. 2. — Normal wear.

Hard flange.

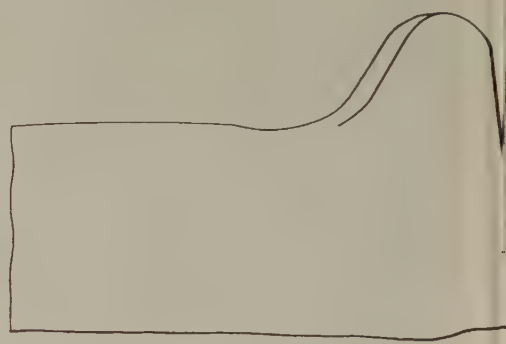


Fig. 3. — Flame-hardened flange. V = 300 mm/min. H_{RC} 61 ± 2.

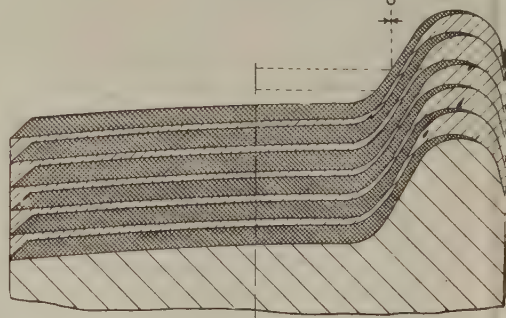
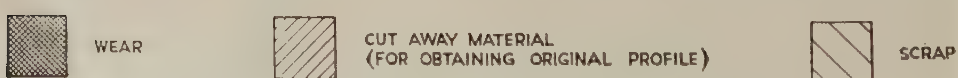
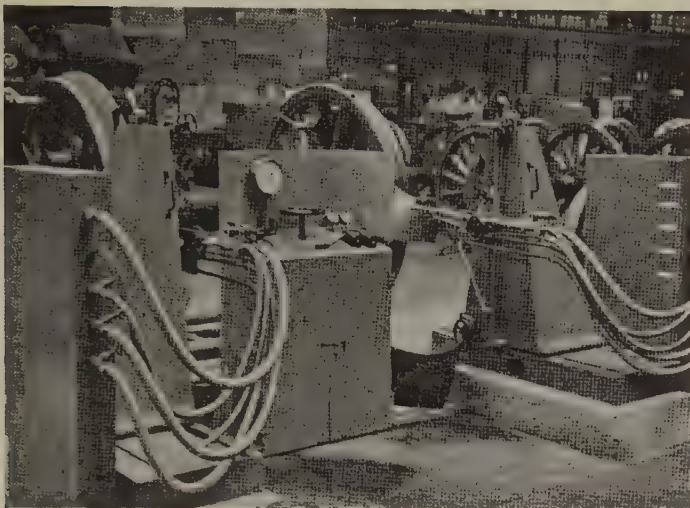


Fig. 4. — Little wear better use of material.



Diagrams showing flange wear on flame-hardened and untreated locomotive tyres.



Operating side of the plant showing the controls.

Wheel-rotating mechanism with the counterbalance weight in position.

ing acute curves, several years of useful tyre life are lost during re-turning to bring the tyre back to standard profile.

As a result of experimenting on the problem of reducing flange wear, the Peddinghaus organisation is now manufacturing a semi-automatic plant for flame- hardening locomotive wheel flanges, a feature of which is the use of oxygen—town gas as the heating medium. A comparison

between tyre wear on normal and flame-hardened tyres is shown in the accompanying diagrams.

Design and operating features.

The plant is semi-automatic in operation. An automatic temperature indicator known as the Peddinghaus Milliscope is designed for dealing with a rise in temperature of over 400° C. per sec., and it is claimed that this instrument is very accurate and ensures consistent results. The equipment is intended to deal with all types of wheels irrespective of design or size. The rate of hardening is between 12 in. and 16 in. per min., and for a wheel of approximately 3 ft. 6 in. dia., town gas consumption is stated to be 210 cu. ft. and of oxygen 126 cu. ft.; town gas is fed at a pressure of 4.2 lb. per sq. in. The hardening is progressive and the water quench is placed just behind the specially designed burners. The machine may also be used for softening the flange by bringing the cooling quench into operation further away from the burners.

Counterweights are clamped to the wheels during the process so that the correct wheel balance is secured, thus enabling the wheels to rotate at a constant speed past the burners. These weights, which in fact compensate for the absence of the connecting rods, have a simple and rapid-action clamp, enabling them to be attached and removed in a minimum time.

The method of operation is particularly simple. The whole plant takes up comparatively small floor-space and is driven by a 1 1/2 HP motor. The axle, together with the two wheels, rests on four rolls in such a way as to prevent any lateral movement.

Two of these rolls are connected to a shaft fitted with a chain sprocket and are driven through a gearbox having an infinitely variable speed between two limits. The distance between the sets of rolls may be readily varied to accommodate wheels of from about 30 in. to 90 in. dia. The driven rolls thus rotate the wheels past the burners, and quench at a constant speed, regulated to obtain the correct temperature to produce the depth of hardening required.

Temperature control.

This pre-determined temperature is accurately « watched » by the Milliscope, which is virtually a pyrometer functioning so rapidly that for all practical purposes there is a complete absence of time lag. If the wheels rotate too slowly, thereby causing the flange to get too heated, the speed is slightly increased to ensure that the correct temperature is maintained; should the temperature be below that required, then the speed is reduced so as to increase the heat input to the flange and so maintain the correct temperature. The illustrations show the machine hardening two flanges simultaneously.

It is claimed that the life of a tyre of one type of locomotive was approximately 107 000 miles with an unhardened flange; this was increased to 214 200 miles when the flange was flame-hardened.

It is further claimed, as a result of experiments already carried out, that flame-hardened tyres assume a smooth surface and do not wear the track to the same extent as do normal tyres. The plant is distributed in the British Isles and British Dominions by Surfard Limited.

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